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N. C.

March 30th 1713.

Mr Desaguliers's Course Of Natural Experimental Philosophy:

Under Four Heads,
viz.
Mechanicks, Hydrostaticks,
Pneumaticks, Opticks.

M DCC XIII.

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* Naturall philosophy ought not to be deny'd ye name of a Science, because founded only on Suppositions, from whence yre may seem to flow only a Contingent sort of knowledge; when these Suppositions often carry in ym ye weight of Demonstration, by shewing from experiments, yt such effects may be produc'd from such causes, whether they are really so, or not. For as Nature may possibly work ye same effect by difft causes, so is it no wonder, that we shou'd find* difft ways of explaining it, & build more yn one Hypothesis to solve ye same Phænomenon.

Bartholin. Spec. Phys. c. 1.

* — Quid in hoc mundo sit eorum, ponere certum
Difficile est: Sed quid posit fiatq per Omne,
Id doceo: Pluresq sequor disponere Causas,
E quibus una tamen sit & hac quoq Causa necesse est.

Lucret. lib. 5.

Of Naturall Philosophy.

Naturall philosophy is that *Science, which gives ye Reasons & Causes of these Effects & Changes, which naturally happen in Bodies.

And, yt we may not be deceiv'd by false notions, wch we have embrac'd wthout Examining, or yt we have receiv=ed upon ye Authority of others; we ought to call in Question all such things as have an appearance of Falshood, yt by a new Examen, we may be led into Truth.

This Examen is to be made by Suppositions, wch we may rely upon, wn they agree wth Experiments; but if only one Ex=periment is contrary to any Supposition, That Supposi=tion must be rejected, & a new one made, till we find it agree wth all or Experiments.

Therefore we must not go about to define a Cause, unless we know its Effects, or lay down a generall proposition, if we doubt of any of ye particulars, yt it comprehends; lest we run into Errours, & take things for granted, wch have been found contrary to Experiments & Mathematicall Demonstracons. An Instance of ys may be giv'n in wt has formerly been sd of Heat & Cold, viz. That Heat unites Homogeneous Bodies, & separates Heterogeneous, & yt Cold unites Heterogeneous Bodies; all wch we find to be altogether false in severall Instances:

1. Mix & melt Gold & Silver togethr, & ye Fire will not separate ym. Neither will it separate 2 parts of Brass mix'd wth 1 of Copper.
2. It rather unites yn separates such Heterogeneous Bodies, as have an aptness to Coalition; as in making plaisters & Ointments &c. & in uniting Salt-petre & ashes into redu=

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* Tis noted how by those y^t defend Aristotle's Definition of Heat & Cold; That by Homogeneous & Heterogeneous is not meant a Likeness or unlikeness of Nature but only of Substance or Consistence of Matt^r: As Heat is apt to confound Pitch & Wax, one metall w^th another, & in digestion to congregate Juices, tho' unlike in y^eir nature yet being of y^e same consistence & texture of p^ts, into one common Liquor. And in y^s Sense y^t y^e Definitions hold good. See Burg. Phil. part.1. Tr.3. Diss.2. c.1.

rable a Body as Glass. (2

* Fire only dissociates ye pts of Bodies & subdivides ym into minute pticles, without respect to yeir being Homogeneous or Heterogeneous; wch is Evident in Boyling water & othr Liquors, whose Steams condense into ye same Substance again. And in Distillation, wn all ye pts are in a confusion, upon slackening of ye Heat, or ye pts receding fm it, wn driv'n into ye Receiver, they take place according to ye Specifick Gravitye.

Such pts also as are most easily separated, are carried out first, as in ye Distillacon of Mans Blood; first water, yn Spirits & Salt, yn Oil, ye Earth & alkali remain togethr, because of an equall degree of Fixedness, tho Heterogeneous. Cold dos not always unite Heterogeneous Bodies, but separates ym. as in ye Urine of Healthfull people, it causes a Sediment, wch is again dispers'd & made to dissappear by Heat. And by Frost ye Strength of wine is separated & unfrozen in ye middle of ye Vessell. Straw, Dust, Wood, &c are no furthr united in Ice, yn as they are fetter'd up in ye Frozen Water.

By Elements ye Philosophers meant ye most Simple Bodies, of wch they s'd all ye Bodies, yt were, are made; & wch may be extracted fm all Bodies. But they have been mistaken in constituting yeir Elements, because they did not so much explain ye Nature of ye things, as wt Senses yse things excite in us.

They yt consider'd things, as they affect ye Sight, made only 2 Elemts, The Lucid & Opake; tho they gave but a blind acct of Light & Colours.

The 4 Elemts yt have obtain'd so long, express'd only ye seuerll ways, yt or Touch is affected: for those, yt establish'd ym, considering Heat & Cold, Moisture & Dryness, suppos'd ym ye properties & primary Qualitys of Bodies, and accordingly constituted 4 Elements:

The

The Earth	They suppos'd	Cold & Dry.	(3
The Water		Cold & Moist.	
The Air		Hott & Moist.	
The Fire		Hot & Dry.	

To Illustrate ys Doctrine, & prove yt These are in, & may be extracted fm Bodies; They us'd to burn a peice of Green Wood, & call ye Cools & Flame, Fire; its Sweat, water; ye Smoak, Air; & Ashes, Earth.

But these can't be Elements acc. to yeir Definitions; for they are not Simple & unchangeable, but may be altered & produc'd de Novo:

The Smoak, wch they call air, may be condens'd into a Liquor.

The Fire is only Subtile Matter, in a Rapid Motion.

The Moisture will produce Caput Mortuum & Oil.

The Ashes, wch they call Earth, will make Glass.

Besides severall Things are not reducible into 4 Heterogeneous Bodies, as Gold, Silver, Diamonds, comon Glass, Venetian Talk, &c. tho' they & ye Chymists have often endeavour'd it; & if they cou'd do it, yet they cou'd not prove yeir Elemts to be unmix'd, because Experiments show ye Contrary.

The Chymists Principles are Salt, Sulphur & Mercury; wch they call Elemts, but erroneously, for these can't be had fm Gold, Glass, Diamonds, Sand &c.; and may be destroy'd & produc'd de Novo. Mr Boyle affirms, yt Quicksilver has been turn'd into water, & Sulphur alter'd, & yt ye Mercurys, Sulphurs & Salts of ye Chymists are not Similar Bodies: Whereas, To be Elemts, each ought not to differ fm those of ye same name, more yn Drops of water do fm One another. Othrs add to yse 3 principles Caput mortuum & Phlegm, i.e. Earth & Water: But yse 5 are producible fm Water alone; & Art can of 2 Elements compound a Body as durable as any in ye World, viz. Glass made of ashes, yt have only Salt & Earth.

The Doctrine of Acids & Alkalies is as faulty as ye foregoing; for none of yse Hypotheses can account for Firmness & Fluid-

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Fluidity, ye Phænomena of ye Loadstone, ye Formacon (4
of a Fœtus, Sounds, & a thousand oth^r things, yt fall under ye
notice of a Philosopher:
And as long as ye Chymists, or any oth^r Philosoph^rs endea=
vour to explain things by a Number of Mix'd Ingredients
in a state of Rest, they will be deficient: Since ye great=
est part of ye Affections of Matt^r, & consequently ye Phæ=
nomena of Nature seem to depend on ye Motion & Con=
trivance of ye small pts of Bodies.
That Philosophy therefore is most reasonable, wch Teaches,
1. That ye Matt^r of Naturall Bodies is ye Same, viz. a Substance
Extended, Divisible & Impenetrable.
2. That since yre cou'd be no Change in Matt^r if all its pts were
perpetually att Rest among ymselves, to distinguish ye gen=
erall Matt^r of ye Universe into a variety of naturall bodies,
it must have motion in some or all its pts, wch must be variously
determin'd. And tho' it is manifest to sense, yt yre is
Locall motion in Matter, yet Motion is not included in
ye Nature of Matt^r, nor coævall wth it; as being as much
Matter, wn att Rest, as wn in Motion. And tho' it be hotly
disputed, How Matt^r came by yt motion, by those yt acknow
ledge not an Autho^r of ye Universe; yet, since a Man is
not ye worse Naturalist for not being an atheist, we al=
low, yt ye Origin of motion in Matter, as well as of mat=
ter, att first is fm God.
3. That Locall Motion is ye cheif Principle amongst Second Cau
ses, & ye cheif agent of all yt happens in Nature; Bulk,
Figure, Rest, Situation & Texture being ye Effects of mo=
tion, as in a Watch or Key 'tis Motion, yt makes all usefull.
We suppose Matt^r att first pull'd into small peices, of wt Shape
any one shall please to imagine; we'll say Cubick, as ye most
obvious; yn every one of yse pts being turn'd swiftly round
its own Centre, & also anoth^r Centre comon to all its pts, ye
Corners must be worn off fm sev^ll of yse parts & a fine Dust
be made by yt Friction. The Small Dust is ye Materia
Subtilis, or 1st Elemt; ye Cubes yt have been rubb'd round
into

‡ The Æolipile is a Close, hollow vessel of Brass or Iron, wth only one small mouth, att A, wch att first is fill'd only wth air & putt over ye Fire till yt ~~air~~ by rarefaction is in great measure evaporated; yn its neck being imerg'd in water, ye water getts in as fast as ye Air condenses again by Cold: Then ye Æolipile being laid on ye Fire upon its side EC, ye water wth in melts by degrees into Vapours wch playing abt ye uppr part DB force one anothr out att ye mouth A wth great precipitacon; & carrying ye Air along wth them make a Wind, in no respect difft as to its pperties fm yse winds so constantly blowing o'er ye Surface of ye Earth. Whence we conclude wth good reason, yt Winds are chiefly caused by Vapo[r]s dispers'd & dilated in ye air, wn they break forth wth violence fm any close place (as fm cavitys of mountains) into an Open & Free Space; or are any ways putt into a violent & rapid mocon, wth wch they affect ye air.

{Rohault. part. 3. c. 11.

into Globules, make ye 2d Elemt. of not so swift a Mo=
tion, as ye first, wch is agitated between ye Interstices of ye Globuli. The Cubes, yt have not lost yeir Shape by having yeir angles much broken off, make ye 3d & most unactive Elemt.

To illustrate ys Hypothesis, take Cubes of Clay & shake ym togethr in a Round Box, till some of ym are become pretty near Round. The Dust repr.sents ye Materia Subtilis, the Roundish peices of ye Globuli ye 2d Elemt, & such as have not much chang'd yeir Shape ye 3d Element.

Tho' we cannot Positively say, That Mattr was thus divided; yet since we find such kind of parts in Bodies, we shall look upon it as probable, because all Experimts confirm, & none contradict ys Hypothesis.

That Firmness & Fluidity, Heat & Cold, Odours, Savours, Co=lours & Sounds depend upon ye Shape, Size & Motion of ye pts, may appear fm Oil of Tartar per Deliquiu pour'd on Oil of Vitriol, will cause it to Boil & Fume &c.

A Solid Body will loose its Smell & Firmness by ye Infusion of one Liquor & recover Both by ye Infusion of another; as Camphire will be dissolv'd & lose its Scent by ye Infusion of Oil of Vitriol, but by pouring in Water ye Smell & Solidity will be restor'd.

Sal Armoniack dissolv'd in Water makes a mixture colder yn each is singly.

Water will be so rarified by means of an ‡ Aeolipile, as to become lighter yn air; & if ye Hand be held near ye mouth of ye Aeo=lipile, ye water yt strikes on ye hand, will again be con=densed & become as heavy, as at first.

Severall More Experimts prove this Hypothesis.

Now, if Firmness & Fluidity, Heat & Cold, Smells & Savors depended only upon a mixture of Ingredients, as some affirm; then

1. Two Cold things wd continue Cold, when mix'd.
2. a Liquor without Smell cou'd not give a Scent to anothr Liquor.
3. Two Fluids, wn mix'd, wou'd continue Fluid.

But ye Contrary is shewn by sevl Experiments.

The Extension of Mattr & its Impenetrability are self-evident: and its Divisibility appears fm ye Ductility of Gold; for an ounce of Gold will guild a large peice of Silvr, wch being drawn into Wire, will likewise yn be all over guilded, tho'

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ye Wire be made so small, as to reach above 150 miles.
See an account of ye Ductility of Gold giv'n in square lines in S. Clark's Rohault, part 1. Cap. 9.

A Candle seen by a whole Multitude shews the Divisibility of Matter to be Infinite, because Rays of Light must enter every man's Eye; for unless those fine parts of ye Fluid made an Impression on ye Retina of ye Eye, ye Candle cou'd not be seen.

Mechanicall Principles.

The Quantity of Motion, which we sometimes call Momentum, or sometimes simply Motion, is That Force & Energy, by wch a Body changes its place. The Quantity of Motion may be encreas'd, Either 1st, by keeping ye same Quantity of Matter & augmenting ye Velocity; or 2dly, by keeping ye same Velocity & encreasing ye Quantity of Matter; or 3dly, by Increasing Both. and yrefore ye absolute Force, by wch Bodies are mov'd, is known by ye Multiplication of yeir Celeritys into yeir Matter or Weight.

As for Example in ye 2 Bodies A, B, A B
Lett A be 5lb & B 2lb, lett ye Velocity, by wch A is mov'd be 6°, and B 4°; then ye degrees of Motion in A will be 30, & B will have 8° of Momentum or Motion.

Suppose A to have 12lb, & B 2lb, lett A have 4° of Velocity, & B 30°; ye Quantity of Motion in A will be 48°, & in B 60°.

From hence it follows, yt any little Body may have its Motion equall to yt of any great Body, viz. If ye Velocity of ye Little be so much greater yn ye Velocity of ye Great body, as ye Quantity of Matter in one is greater yn ye Quantity of Matter in ye other Body, i.e. When Both have yeir Velocities reciprocally proportionall to yeir Weight, yeir Momenta or Quantities of Motion will be equall.

As for Example, Lett A be 50lb & B 2lb, lett ye Velocity of A be 3°, & of B 75°; Now 50 has ye same* proportion to 3, as 75 to 2, and yrefore ye Quantity of Motion in A, wch is 3 × 50 or 150, is equall to ye Motion in B, wch is 2 × 75 or 150.

*viz. Reciprocal proportion.

If ye Velocities of Bodies are equall, yeir Quantities of Motion will be as their Matter wch is contain'd in them. And

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Lucret. lib. 1. v. 359.

Deniq cur alias aliis præstare videmus
Pondere res rebus nihilo majore figurâ?
‡ Nam si tantundem est in lanæ glomere, quantũ
Corporis in plumbo est tantundem pendere par est;
Corporis officium est quoniam premere oĩa deorsum;
Contra autem, Natura manet sine pondere Inanis.
Ergo &c.

‡. Wch Sr Isaac Newton has improv'd into a Demonstration, in his Princip. Math. lib. 1. prop. 6. (v.g.) That ye Weight of all Bodies is Proportionall to yeir Quantity of Matter; & therefore if all Space were full of Matter, ye Specifick Gravity of one Body wd be equall to yt of another, neithr cd yre be any Reason why all Bodies shd not Gravitate equally.

And therefore, Since all Bodies (abstracting f^m y^e Resistance (7 of Air) descend equally fast, y^e Moc̄on, w^ch Bodies acquire by y^eir gravity in descending, will be as y^eir Quantity of Matt^r. As a Feath^r descends as fast in a Vacuo, as a Pound of Lead; But suppose y^e Lead a 1000 times heavier y^n y^e Feath^r, y^e Momentu^m of Lead will be 1000 times greater: Gravity is y^e cause of y^e descent of Both, therefore y^re is a 1000 times more Gravity requir'd to make y^e Lead descend, y^n y^e Feather; so y^t y^e Feath^r, w^ch has a 1000 times less Matt^r y^n y^e Lead, may descend w^th as great Velocity as y^e Lead, y^e Momentum of y^e Lead being 1000 times greater y^n of y^e Feather.

And consequently, Since all Causes are proportionall to y^eir Effects y^e Gravities of Bodies w^ch produce y^eir Moc̄on downw^ds, will be likewise proportionall to y^e Quantities of Matt^r in Bodies. And therefore y^e Quantity of Matter in any Body may be Estimated by its Weight; & therefore, if an Inch of Lead be 6 times heavier y^n an Inch of wood, y^re must be 6 times more Matt^r in y^e Inch of Lead y^n in y^e Same Bulk of wood.

‡ And hence may be drawn a good Argument for a ‡ Vacuu^m; for tho' we grant y^e Existence of a Materia Subtilis, yet y^e Question will return, How y^t Matter comes to be so Fine, but by having Void spaces? we must Suppose y^e Pores of all Bodies to go in a Straight line & Horizontall, oth^rwise y^e Materia Subtilis will be reflected, & so consequently not fill up all y^e Pores.

The whole Effect of Mechanicall Engines is to diminish y^e Velocity of y^e Weight to be rais'd; so y^t y^e Quantity of Moc̄on it will have, may be no more y^n y^e Quantity of Moc̄on in y^e Power y^t raises y^e Weight.

Suppose a Man can raise by his Strength, w^thout an Engine, only 10 lb of Weight w^th a determinate degree of Velocity, 'Tis not possible for any Man to raise 100 lb w^th y^e Same degree of Velocity; yet, by y^e applicac̄on of an Engine, a Man can raise 100 lb w^th a 10^th part of y^t Velocity.

Now all y^t y^e Engine does, is to diminish y^e Velocity of y^e Pondus, so as to make its Moc̄on no great^r y^n y^e Moc̄on of y^e Pow^r raising it.

See Plate 3, Fig. 1. As may be seen in y^e Vectis, w^ch we suppose as a Mathematicall, rigid, inflexible Line, only moving round y^e point C w^ch is call'd y^e Fulcrum; A C & C B are call'd y^e 2 Brachia. In this Statera y^e

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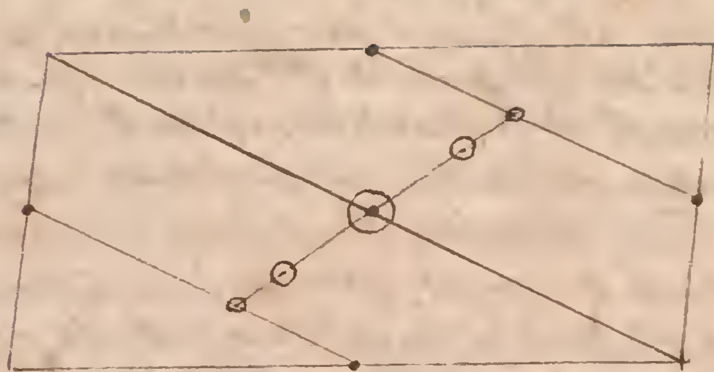

• Centre of one Line
⊙ Comon Centre of 2 Lines
⊙ Centre of a Triangle
⊙ Com Centre of ye 2 Triangles, or Centre of the whole Surface.

† To find out ye Centre of Gravity in any Body; we must 1st begin wth Lines, fm thence go to Surfaces, & fm Surfaces to Solids. In any giv'n Line ye Centre of Gravity is just in ye middle. To find out ye Comon Centre of 2 Lines; Join ym togethr & yeir Comon Centre will be in a right line drawn fm each of yeir proper Centres, & in ye middle point of yt right line, provided ye 2 lines were Equall: but if they are unequall ym in a point so much nearer ye greatr line, as yt line is greater yn ye othr. Having found out ye Comon Centre of 2 lines, add a 3d & make a Triangle; whose Centre shall be in a line drawn fm ye Com Centre of ye 2 first lines & ye propr Centre of ye last, & in a point so much nearer ye Centre of ye 2 lines yn ye Centre of ye last line, by how much longer ye 2 lines togethr are yn ye one last Line.
Seeing a Surface of any Figure may be reduc'd to Triangles, by joining ye Centre's of 2 Triangles togethr after ye same manner, still nearer proportionally to yeir being bigger yn one anothr; We may come by ye Centre of any Surface. And by joining after ye same manner ye Centre's of Surfaces, we find out ye Centre of Gravity of any Solid.

yᵉ 2 Brachia (thô one be longer yⁿ yᵉ other) are equally heavy; & conseq. BC keeps in Æquilibrio AC, wᶜʰ is divided into 10 lengths, each of wᶜʰ is Equall to CB. Lett Q be yᵉ Weight wᶜʰ is to be found out, by hanging any giv'n weight P upon yᵉ Brachiū A, & moving it up & down, till it makes an Æquilibriū, You will find out yᵉ Weight of Q: for since P in yᵉ distance 5 is æquiponderate wᵗʰ Q, it follows yᵗ Q is yᵉ Quintuple of P, as it is here demonstrated.

Now Suppose, yᵗ if yᵉ Brachia are Equall, a Man cᵈ only raise 10 ℔; yⁿ I say, if you alter yᵉ Brachia & make AC 10 times longer yⁿ BC, He can by yˢ Engine raise 100 ℔: For, because BC is but $\frac{1}{10}$ of AC, yᵉ Space Bb will be but $\frac{1}{10}$ of Aa, & conseq. wⁿ B moves it will have but yᵉ 10ᵗʰ pᵗ of yᵉ Velocity of A. But by Supposition, The force of A is so great, as to raise wᵗʰ yᵗ Velocity a Body of 10 ℔; therefore it will raise wᵗʰ $\frac{1}{10}$ of yᵗ Velocity a Body of 100 ℔. Fᵐ hence it follows, yᵗ yᵉ Weight of A will weigh 10 plac'd att B; for because Aa is greater yⁿ Bb, the Velocity of 1 ℔ att A will be 10 times greater, yⁿ yᵉ Velocity of 10 ℔ att B: & therefore yeir Quantities of Motion will be equall, yeir Velocities being reciprocally proportionall to yeir Weight. Since yⁿ yᵉ 2 Bodies have equall Motion or equall forces wⁿ mov'd; those Forces being Contrary or Acting Contrary to one anothᵉʳ, will destroy Each yᵉ othᵉʳˢ Motion, & keep an Æquilibrium.

A point in any Body so plac'd, yᵗ all Mattᵉʳ on every Side gravitates equally, is call'd yᵉ Centre of Gravity of yᵗ Body. The Centre † of Gravity is not always in yᵉ Centre of Magnitude; as in yᵉ Staterâ Romanâ, where 'tis not requir'd yᵗ yᵉ Short Brachiū shᵈ have an Equall Quantity of Mattᵉʳ to wᵗ yᵉ Long one has.

The Centre of Motion is yᵗ Point, round wᶜʰ a Body moves, every point of it describes Circles, whose Centres are in yᵉ Centre of Motion. The Centre of Gravity of all Bodies descends as much as it can: If a Body be suspended by its Centre of Gravity, it will retain any giv'n position; for in yᵗ case, yᵉ Centre of Gravity cannot descend: If yᵉ Centre of Gravity be distant fᵐ yᵉ Centre of Motion, then, if yᵉ Centre of Gravity be out of its perpendicular, yᵉ Body will turn round, 'till it be just under its Centre of Motion, for yⁿ it has descended as much, as it can.

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Plate 3, Fig. 2. Lett AB be a Beam, whose Centre of Mocon is att m above ye centre of gravity c; if it were turn'd out of ye Horizontall position, ye Centre of gravity must ascend, suppose to k, & yrefore if ye Body be left to its self, 'twill turn round, 'till ye Centre of Gravity comes again to its former position.

In a Ballance, ye Axis & ye Centre of Mocon is a little above ye Centre of Gravity; for if it were exactly in it, it wou'd retain any given position: But by being above it, ye Beam of ye Ballance must, wn in Æquilibrio, settle it self in an Horizontall position.

The Centre of Mocon may be just below ye Centre of Gravity, but if you move ym never so little out of an exact perpendicular, ye Scales will not be in an Æquilibriū; but as soon as you lett ye Balance hang freely, ye Centre of Gravity will gett below ye Centre of Mocon.

Mechanicall Powers.

Definition 1. A Weight is any Body to be rais'd or mov'd.

2. A Power is yt Force by wch a Weight is rais'd, whethr it be a Force, wch draws, or pushes, or strikes, or a Weight wch gravitates, for a Weight is a powr in reference to a Heavy Body, wch it may move.

3. The Absolute Gravity of a Body, is its endeavr to descend in a free Medium.

4. The Relative Gravity of a Body, is its endeavr to descend wn it touches something else besides ye pts of ye Mediū, & this is always less yn ye Absolute.

5. Æquilibrium is, wn yre is ye same Quantity of Mocon in ye Power, as yre is in ye Weight, because those Mocons being Contrary, ye One destroys ye other.

6. The Centre of Mocon, Fulcrum, or Fix'd point are all ye Same.

7. The line of Direction of a Powr or Weight, is yt, in wch it endeavours to Move; In a Heavy Body, ye Right Line, by wch it endeavrs to descend; In a Powr, ye right line, by wch a Powr draws or pushes a Weight to sustain it. If C draws A over B, BC is ye line of direction of ye Powr, & AD yt of ye Weight, by wch it resists ye Traction. (Plate 1, Fig. 1.)

8. The Application of a Powr to a Vectis or Leavr is ye angle, wch ye Line of direction of yt Powr makes wth ye Leaver, as ye Angle ABE. (Fig. 2.)

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9. The Distance of a Pow^r or Weight, is a Line drawn f^m y^e (10
Fig. 2.} Fix'd point, perpendicular to y^e Line of Direction, as CF.
10. In all Regular & Homogeneous Bodies, y^e Centre of Gravity is in y^e Centre of Magnitude.

Supposition 1. We must Suppose y^e Earth Flatt, because y^e greatest Engines are but as a point, w^n compar'd w^th y^e Surface of y^e Earth.
2. W^n Heavy Bodies fall freely, they make lines perpendicular to y^e Earth, meeting in y^e Centre of y^e Earth; & y^t we are to Suppose Parallel
3. The Engines w^ch are imperfect, we must Suppose to be perfect, y^t by such a Supposition we may y^e bett^r find w^t they'll do; as y^t Bodies are perfectly Hard, Smooth, & Homogeneous, Lines straight w^th out Weight, Thickness or Flexibility, & Cords extreamly pliable.

Axiom 1. To raise a Weight w^th an Engine, The Velocity of y^e Power must be encreas'd, & y^t of y^e Weight diminish'd.
2. The Centre of Gravity always descends as low, as it can.
3. A Body can fall no lower y^n it is, unless its Centre of Gravity descends.
4. If all y^e Weight of a Body were reduc'd into its Centre of Gravity, it w^d move as before.

Probleme. How to make a Heavy Body Rise of its self.
The Body must be a double Cone of Wood or any Solid Matter, as
Fig. 3.} ABA. Sett 2 long flatt peices of Wood on a Table w^th one End upon 2 other cross peices, as CCD, So as to raise y^m almost as high above y^e Horizontall plain (att y^e other End) as is y^e difference of y^e Radius att A to y^t at B; then lay y^e Body ABA upon them att D, where they must meet in an Angle, & it will roll up to C, if y^e distance CC be no greater y^n y^e distance AA. The Reason follows
W^n y^e Body is laid on att D, y^e Centre of Gravity, w^ch is in y^e middle of y^e Diameter B where it is cut by y^e axis AA (because y^e Body is regular & homogeneous) is higher, y^n it is w^n y^e Body has roll'd to CC. Now because y^e Centre of Gravity endeavo^rs to fall as low as it can, y^e Body will roll to CC, where 'tis low^r y^n it was before, tho' its Supporter be higher; As will appear by holding a thread Horizontally f^m D to E, for if y^e Body touch y^e thread att D, it will be below it, w^n it comes to E.

Theoreme. What is said of y^e descent of a Heavy Body, is to be understood of its Centre of Gravity: Because, unless y^e Centre of Gravity can fall, y^e Body can't, by y^e foregoing proposition.

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For yᵉ Body ABCD, wᶜʰ stands upon an Horizontall plain FC, can= (11
Plate 1,} not fall towards F, where it inclines; because its Centre of Gravity
Fig. 5.} E wou'd rise, wᶜʰ appears by drawing of yᵉ Arch E about yᵉ point
Fig. 6.} B. But ABCD will fall, because its Centre of Gravity can fall, as appears by Construction.

Scholium. Since yᵉ First Impulse of a Heavy Body downwᵈˢ is begun at its Centre of Gravity; & yᵗ yᵉ Centre of Gravity endeavoʳˢ to gett as low as it can; A Heavy Body must endeavoʳ to descend in a
Fig. 4.} line (call'd yᵉ Line of Direction, as EG or CO) drawn frᵐ its Centre of Gravity to yᵉ Earth, or Centrū gravium, wᶜʰ is yᵉ lowest place: and if it can't move in yᵗ Line by reason of yᵉ interposition of a Plane (so inclin'd, as not to hinder yᵉ Centre of Gravity frᵐ descending) will fall obliquely by sliding or rolling, so as to gett into yᵉ Line of Direction, as fast as it can.

Coroll. 1. Hence also will yᵉ Body D slide, & yᵉ Body F roll upon yᵉ inclin'd plane ABC (fig. 4) to gett to yᵉ line CO parallell to its Line of Direction EG.

2. Hence also will Bodies stand upon an Horizontall plane, if yᵉⁱʳ Line of Direction falls wᵗʰin yᵉⁱʳ Basis. Thus yᵉ Body of Fig. 5 will stand, & yᵗ of Fig. 6 fall. A Bowl will easily change its place, because
Fig. 7.} its Base being but one point, its easy for its line of Direction EG to fall out of it. This is also yᵉ Reason, why it is almost Impossible to sett a Straight Stick or Needle upright on a Smooth Horizantall Table, or Plane. Because yᵉⁱʳ Lines of Direction EG fall wᵗʰout yᵉⁱʳ Bases. What is said of yᵉ Centre of Gravity, may be also understood of yᵉ comon Centre of Gravity of 2 heavy Bodies, as we shall show in yᵉ Balance.

Of the Balance.

Prop. 1. Theor. When a Ballance has its Brachia of yᵉ same length & weight, yᵉ Power & yᵉ Weight are Equall.

2. Probl. To make an Æquilibriū wᵗʰ an Horizontall Balance:
Fig. 8.} Lett yᵉ Weight D be to yᵉ power E, as yᵉ distance CB of yᵉ powʳ to yᵉ distance AC of yᵉ weight, & so vice versâ. Thus will yᵉ Centre of Gravity be brought under yᵉ Centre of Motion.

3. Theor. By encreasing yᵉ Velocity of yᵉ Power, yᵉ Velocity of yᵉ Wᵗ will be lessen'd, as has been shewn in yᵉ Statera Romanâ.

4. Probl. Knowing yᵉ Weight of 2 Heavy Bodies, apply'd to yᵉ Ends of a Ballance of known length; To Find yᵉ Comon Centre of
Fig. 9} Motion upon yᵗ Balance: Lett AB, yᵉ Ballance be 24 inches long & yᵉ Weight D 12 ounces, E 6 ounces. To find yᵉ Fix'd point, wᶜʰ

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wch ye Balance being Suspended, ye Weights will hang (12
Plate 1, Fig. 9.} in Æquilibrio. Find a 4th proportionall to 18 : 6 :: 24, wch will be 8 inches for AC. i.e. as 18 = ye Sum of ye 2 Weights : is to 6 ye Sum of ye least weight :: So is 24 inches, ye whole length of ye Balance : to 8 inches = AC ye Distance of ye fix'd Point fm yt End of ye Balance, wch has ye biggest Weight. 2. E. F.
Tho' ys is True in ye Theory, yet it won't hold in ye Ballance. Because ye Balance AB, wch we suppose wthout weight, cannot be really so, because ye 2 Brachia are not of ye Same wt. Hang ye Weight F = D + E att C (wch, by Ax. 3. won't alter ye Effects of ye 2 weights D, E:) yn hang att I ye Centre of Gravity of ye Ballance, ye weight G = to ye Balance's weight; yn considering CI as a Balance laden wth its 2 weights att its Ends C, I, Find out O ye comon Centre of Gravity, as taught, viz. F + G : G :: CI : CO.
Prop. 5. Probl. Knowing ye Length & weight of a Balance, wch has att one of its Ends a Body of known wt; To Find ye Fix'd point, abt wch ye Balance & wt of ye Body shall remain in Æquilibrio : Find a 4th pportionall to 24 : 16 :: 6 :
Fig. 10.} wch will be 4 inches for AC; i.e. As ye wt of ye Body togeth wth ye wt of ye Balance : is to ye wt of ye Balance :: So half ye length of ye Balance : is to AC ye distance fm ye wt of ye Body to ye Fix'd Point. (Length of ye Balance = 12 inch. wt of ye Balance = 16 oz. wt of ye Body D = 8 oz.)
6. Probl. How To make a Deceitfull Balance, wch being empty & also laden wth unequall weights, shall remain in Æquilibrio.
Fig. 11.} Lett ye length AC be to BC, as ye weight of ye Scale E, to ye wt of ye Scale D: The Æquilibriu will be kept, if ye Scales are laden wth weights, yt have ye same Ratio to one another as 11 to 12; But ye Fraud will be detected by changing ye place of ye Weights.

Of ye Leaver.

Prop. 1. Theor. The Leaver is reducible to ye Balance, ye Weight & Animal power being ye same as ye diff.t weights in ye Balance, & ye Fix'd point ye same as ye Centre of Motion.
2. Theor. The 3 first propositions of ye Balance are True concerning ye Leaver. C is ye Fulcru or Fix'd point, E ye Power
Fig. 12, 13, 14, 15.} apply'd att B, & D ye weight apply'd att A. Fig. 12, is a Leaver of ye 1st kind, as are also Sizzers, Pinchers, Snuffs, &c. This Leaver has ye Power att one end, ye weight att ye other, &

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✶ To ye Leaver of ye 3d kind are likewise reducible all ye Bones in a Mans Body; where ye Fix'd-point is att one End, in ye Joint; ye Weight att ye oth:r, any Limb or pt to be lifted up; & ye Pow:r in ye Middle viz. a Muscle fix'd somewhere abt ye middle of ye Bone.

✳ Hence is it, yt We find it easier, by Experience, to Lift any wt wth our arm bent att Right-Angle, yn eith:r Stretch'd out, or too much contracted.

Fm ye same Reason perhaps we may account, why in Building, an arch exactly Semicircular is allow'd to be of more Strength, yn either one of a greater or less Circumference; viz. because (by Prop. 31. l.3, Euclid. Elem.) The Angle in a Semicircle only is a Right angle, & consequently of greater power & Effect, than any angle in a Segment greater or less yn a Semicircle, wch is but an Oblique angle.

ye Fulcrum in ye middle. Fig. 13 is a Leaver of ye (13
2d kind, as are also ye Oars & Rudders of a Boat, Cutting-Knives fix'd att one End, & Doors moving on Hinges. These Leavers have ye Wt in ye middle, ye Power att one End, & ye Fulcrum att ye other. Fig. 14 is a Leaver of ye 3d kind*, as are also Ladders, yt are tak'n up by ye middle to be rear'd agt a Wall: This Leaver has ye Power in ye middle, ye Wt att one End, & ye Fulcrum att th'other. Fig. 15 is a Bended Leaver, or of ye 4th kind; but it may be reckon'd as well a Leaver of ye 1st kind, because its Fulcrum is betwn ye Power & ye Wt. Wn you draw a nail wth a Hammer, it becomes a bended Leaver. In a Leaver of ye 1st or 4th kind, ye Wt & ye Power may be Equall, as it must happen wn AC is equall to BC: ye Power may be greater yn ye weight, as wn BC is greater yn AC: or ye Wt greater yn ye Power, as wn AC is greater yn BC. (Plate 1, Fig. 12, 15.)

In a Leaver of ye 2d kind, ye Wt must be greater yn ye power, because its distance fm ye Fulcrum will be always less yn ye Powers distance; For wherever D is apply'd, AC will be a part of BC, & yrefore must always be less yn its whole BC. (Fig. 13.)

In a Leaver of ye 3d kind, ye Power must be always greater yn ye Wt, because CE ye distance of ye Power will always be less yn AC, of wch it can be but a part. (Fig. 14.)

N.B. In all these cases an Æquilibrium is Suppos'd.

Prop. 3. Theor. A Power yt draws or pushes a Leaver at Right-angles, has greater Effect, yn att Oblique-angles.

* Demonstration. Since ye Force of a Power depends upon its distance fm ye Fix'd point; & since (by Def. 9) ye Distance of ye Power is a line drawn perpendicular to ye Line of Direction. 'Tis plain by Construction, yt CB ye distance of ye Power at Right-angles is greater, yn CF ye distance of it apply'd att Obtuse-angles, or CK att Acute-angles, drawing towds I. (Fig. 16.)

For since (by 15 Def. 1 Element. Euclid.) CF = CL = CK; & CL, being part of CB ye distance of ye Power drawing att G, & apply'd att Right-angles, is less yn CB (by 9 Axiom 1 Elem.) Likewise CF & CK must be less yn CB: Therefore, a Power apply'd att Right-angles, has a greater Effect, yn if apply'd att Oblique-Angles. Q.E.D.

N.B. CF is ye Distance of ye Power E apply'd att B, & drawing att obtuse-angles, as ye angle CBE; & CK is ye Distance of a Power still apply'd att E, & drawing att ye acute-angle CBI.

4 Theor. If a power, whose Line of Direction is perpendicular to a Leaver parallell to ye Horizon, bears up by means of yt Lea-

Leaver a Weight, whose Centre of Gravity is above ye Lea- (14
ver; it must be greater to Bear it up, wn ye Leave is Horizontall, yn wn it is Inclin'd, & ye Wt rais'd; & greater yet, wn ye Wt is lower: ye line of Direction of ye Powr always remaining perpendicular to ye Horizon. The Reason of this is, Because ye Body O does not hang freely fm ye Leaver, to wch it is fix'd; for if it did, ye distance of ye Wt wd decrease in ye Same proportion as ye Distance of ye Powr does, wn ye Leaver is mov'd out of its Horizontall position: i.e. Wn ye Leaver IB (where IC is ye distance of ye Wt, & CD ye distance of ye Powr) is mov'd into ye Position OD, and ye distance of ye Powr att D becomes CN (by ye 9 Def.) ye distance of ye Weight wd become Ch, if ye Wt was to hang freely fm E; but since ye Body EOM is fix'd to ye Leaver, it endeavours to descend in ye Line of direction OL drawn perpendicularly downwds fm its Centre of Gravity O, wch causes ye distance of ye Wt to be only LC instead of hC; & therefore, ye Bodies Gravity decreasing in greater proportion, yn ye Force of ye Powr (wch is a Wt yt hangs freely) ye Body O requires a less power to bear it up, wn 'tis fix'd upon an Inclin'd Leaver above ye Horizon, yn wn ye Leaver is parallel to ye Horizon. Likewise in ye Leaver AK, if ye Body O or ye Wt was to hang freely fm F, its distance wd be tC decreas'd in ye Same proportion as CQ ye distance of ye Powr; but since ye Body being fix'd is above ye Leaver, ye Line of direction produc'd is KOg, & its distance gC; its Gravity must be greater wn by ye Inclination of ye Leaver it is below ye Horizon. Q. E. D.

Plate 2. Fig. 1.

5. Theor. The Inverse of ye foregoing proposition is True, if ye Centre of Gravity of ye Body be below ye Leaver.

Since ye Demonstration of ys Theorem is ye same as ye oth, a sight of ye Figure is sufficient: Where you may observe, yt in ye Leaver AE ye distance of ye fix'd Wt is MC, whereas it wd be nC if ye Body shd hang freely; & in ye Leaver DG, ye distance of ye Wt is Cn, whereas it wd be CM, if ye Body shd hang freely.

Fig. 2.

6. Theor. If Two carry a Wt upon, or hanging fm ye middle of a Leaver, He carries most, who is nearest to ye Wt. (See ye prop. in Fig.)

Fig. 3. 4.

N. B. Of ye Leaver or Balance is meant, what Archimedes said of his Lifting up ye whole Earth, If he had a place to fix his Instrument. And it was by yse Powers, yt he's Said to have lifted up ye Roman Ships.

Of ye

P

Of ye Pulley.

Prop. 1. Theor. When a Pow: by Sevll Pulleys draws up a Weight, ye upper Pulleys are Leavers of ye 1st kind, & ye lower Pulleys

Plate 2. Fig. 7. } Leavrs of ye 2d kind. For in CE & BH ye Powrs are apply'd att E & H, ye wts att C & B, & ye Fulcra are in ye middle O: But in IK & FG, ye Powrs are apply'd att IF, ye wts att O, & KG are ye Fulcra.

2. Theor. An upper Pulley adds no Force to ye Pow:; because it is a Leaver of ye 1st kind, wth its Fulcrum just in ye middle; &

Fig. 5. } in such a Case, ye velocity of ye wt is not diminish'd, & conseq. yt of ye Pow: not encreas'd.

3. Theor. A Lower Pulley takes off half ye velocity of ye wt, & so

Fig. 6. } doubles ye velocity of ye Pow:. Because, whilst 10 moves 1 Foot, 5 moves 2 Foot.

4. Theor. As one is to ye Numbr of ye parts of ye Rope apply'd to ye lower Pulleys, so is ye Pow: to ye Weight. As for Example,

Fig. 7. } If ye Hand A can raise but 10lb without an Engine, it will, by ye help of ye Pulleys fig. 7, be able to raise 40lb: or one pound att A will keep in Æquilibrio 4lb hanging att ye lowest O, or att D.

5. Theor. wt a Pow: by a Pulley getts in Strength, it loses in swiftness, as it dos by all othr Engines.

Of ye Axle in the Wheel.

Prop. 1. Theor. As ye Radius of ye Axis to ye Radius of ye Wheel, so

Fig. 8. } is ye Power to ye Weight. i.e. as CD : AB :: so is ye Pow: apply'd att A: to ye wt. or rathr, as ye Circumference of ye Wheel = velocity of ye Pow: : is to ye Circumference of ye axis = velocity of ye wt :: so is ye wt: to ye Pow:.

Coroll. This is observ'd in Watches, where ye Radius of ye Wheel in ye Fuzee encreases, as ye Force of ye Spring is weaken'd; yt ye

Fig. 10. } axis of ye Fuzee may be always turn'd round wth ye same force: wn ye Spring is strongest, it draws att A, wn weakest, att B.

2. Theor. An axis in peritrochio is a Leavr of ye 1st kind. AB ye

Fig. 8. } Radius of ye Wheel being ye distance of ye Pow:, & CD ye Radius of ye axis being ye distance of ye wt.

By ye Multiplicaton of Wheels, an Hair may draw up an Oak by ye Root.

To ys Power are reducible, Whimbles, Augers, Windlesses, Trepans, &c.

Of ye

Q

Of the Wedge.

Plate 2, Fig. 11. A Wedge is ye most Simple of Mechanicall Engines; & is a Solid Triangle, usually of Iron, to slide against ye parts of ye Body it cleaveth.

To understand ye Power of ye Wedge, one of ye 2 flat sides, wch incline to one anothr, is to be Look'd upon as an Inclin'd plane, & ye othr as an Horizontall plane: and we must conceive, yt by ye help of ys Inclin'd plane a Powr shall raise a wt, wch without ys Engine it cou'd not so much as bear up.

Fig. 15. Lett ye Triangle DBC, Rectangular att B, repsent a Wedge; D ye point or Edge of it; BC ye Head; &, to be plainer understood, let DB ye length of ye Wedge be twice its Height BC, & ye Basis BD be perfectly Smooth, So yt being apply'd to ye Horizontal Superficies AB (wch also I suppose perfectly Smooth) ye Wedge DBC may Slide upon yt Horizontal plane AB without any difficulty; Then again Let us Suppose yt ye wt E. be hindred fm going to A by ye plane HIK perpendicular to ye Horizon, wch yet does not hinder ye Wedge fm sliding along the Horizontall plane AB, wn it Shall be drawn or push'd fm B towds E by a powr, whose Line of Direction is parallell to ye Horizon; If yn ye Powr pushes ye Wedge DBC regular fm B towards A. in causing it to slide upon ye Horizontall plane AB; It will cause ye wt E to rise up by so regular a Motion, yt its Centre of Gravity E will never go out of ye Line EF perpendicular to ye Horizon: So yt wn ye point B shall come to D, ye point C to F, & ye point D to G, i. e. wn ye Wedge DBC shall be in ye position GDF; The wt E, by ye resistance of ye plane HIK, shall have been forc'd to rise by ye Inclin'd plane CD or FG, wch will have push'd it upwds towds F, so yt it will have risen ye whole length of ye Line DF, wn ye power shall have mov'd ye whole length of ye Line BD or DG, wch is twice DF by ye Supposition.

Since yn by ys Supposition, ye Powr has double ye Velocity of ye wt, it ought to have double ye Force of ye wt; therefore it needs not be more yn half ye Relative wt of yt Pondus upon ye Inclin'd plane CD, to be able to bear it yr, acc. to yt generall Law of Mechanicks, wch we have taken notice of in ye foregoing Engines, viz. That ye Powr encreases proportionally, as its

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its Velocity does encrease; Whence we may easily conclude, (17
That, wn a Powr, whose Line of Direction is parallel to ye Horizon, sustains a Wt by ye means of a Wedge, whose Basis is also parallel to ye Horizon, yt Powr is to ye Wt it bears up, as ye Height of ye Wedge to its Base.

Coroll. Hence. The Sharper ye Wedge, ye more easily it will enter, because GD ye Velocity will be greater in proportion to DF ye of ye Wt: And wn ye Wedge shall be used to cleave a Body, as AB, ye more ye planes EFO, GO, wch make up ye Wedge, are Inclin'd to one anothr, ye parts EG may slip ye more easily along ye Wedge.

Plate 2, Fig. 15. Fig. 12.

N.B. EFO must be taken for an Horizontall & GO for an Inclined plane, & ye Resistance yt ye Body AB makes in its uppr parts, wn 'tis disunited fm its lower, may pass for a Wt, whose Line of Direction is perpendicular to its lowr Horizontall part.

This wch is true in Theory, wd hold in ye Practice, if ye Planes of ye Wedge, & yt plain whereon it slides were perfectly Smooth & ye Wt truly Sphericall; But since these can't be of such a Mechanicall Exactness, ye Practise won't hold: Therefore Percussion is apply'd, wch is ye only Effectuall means, because ye parts of ye Wedge will stick less, wn ye whole is put into a Tremulous Motion.

Scholium. The Reason why a Small Hamer wth a violent blow will not have so much Effect, as a small blow of a Sledge, is, yt a Sledge wth a small force added to its Gravity will have more motion downwds yn a little Hammer wth a Swift blow, because ye motion in a Ratio is made up of ye Pondus & ye Velocity. The Wedge may be reducible to ye Leavr thus, CDA is as 2 Leavrs, whose fix'd points are att B, or rathr, as in this Figure, it represents 2 Leavrs of ye 2d kind, whose Fulcra are in ye comon point A, ye Wts to be mov'd are C, C, & ye Powrs apply'd att B, B.

Fig. 13. 14.

To ys Powr are reducible, Nails, Bodkins, Hatchetts, Knives, Saws, Files, &c. being Wedges fasten'd to Leavers.

Of the Screw.

The Screw is nothing but a Wedge continu'd round a Cylindr in a Spiral mannr, ye Male-Screw AB is an Outside, & ye Female Screw CD is an Inside-Screw.

Fig. 17.

To show bettr how ye Screw works, Suppose ye Wt E to move upon ye Sol=

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Plate 2. Fig. 15. Solid Triangle ICB, fm E to C, it will be ye Same Thing (18 as if ye Solid Triangle had mov'd under it & forc'd it up to F, where it must go, because ye Vertical plane HIK hinders it fm rising in any oth^r Line besides EF: Now because ye pow^r has mov'd ye whole length of ye Line CI, & ye Wt only yt of ye Line EF; ye Pow^r must be to ye Wt, as ye length of ye line EF, wch is ye velocity of ye wt, to ye length of ye Line IC wch is ye Velocity of ye Power.

To Estimate yre fore ye Force of ye Screw, We must look upon ye Cylinder HIPQ as ye Velocity of ye Wt, & ye Thread HKLM

Fig. 16. NOP (if its Helices were unwound & laid att full length) as ye Velocity of ye Pow^r; therefore by ye force of a Screw, ye Gravity of a weight or any oth^r pressure will be lessen'd as much as ye Spiral Line HKLMNOP is greater yn HP or IQ ye perpendicul^r height of ye Screw.

Coroll. Hence, ye closer ye Thread of ye Screw, ye great^r will be its force; because its Thread will be in proportion to its height, & it will move ye Slow^r.

Schol. If long Leav^rs be added to ye Screw, its Force will be still increas'd after ye mann^r as was shew'd in ye Explicaton of ye [Leaver.

The advantage of ys Mechanical Faculty is yt, whereas oth^r Mechanicall Engines cease to Act & ye Wt returns, wn ye Power does not continue to Act; This holds ye Wt & retains all ye Force yt was comunicated to it, wn ye First Mover ceases to Act; because ye Wt pressing ye Cylind^r along ye Axis, pushes ye threads of ye Male-Screw agt yse of ye Female Screw, so yt an Helical mocon is requir'd to unscrew so much as is Screw'd up of ye Instrument. Whereas in oth^r Engines (e.g.) a Pulley or Leav^r, ye Wt will return, as soon as ye Hand ceases to pull ye Rope, or press upon ye End of ye Leav^r.

But yn yre is ys Disadvantage, viz. That a Screw is screw'd up as far as it can go, in a little Time; wch Inconvenience may yet be remedied in Compound Engines, if you make

Fig. 9. it a perpetual Screw & apply it to a Wheel, as in ye Figure, where ye perpetual Screw CDE fix'd to ye Cylind^r AB takes ye teeth of ye Wheel off, & turns it continually ye same way, till it has by means of its Axis drawn up ye Wt G, tho' ever so distant fm it. That ys Pow^r is reducible to a Leav^r, appears fm its being a Wedge, wch we have shewd to be made up of a Leav^rs of ye 1st or 2d Kind.

The First Law of Nature is,

" That all Bodies endeavor to preserve themselves in the same State of
" Motion or Rest; So that if the Body be att Rest, it never comes of its own accord to Motion, but must have something to move it; & if it is once in Motion, it Endeavors always to persist in that motion, according to the same direction, in the same Straight line, nor can it be Stop'd but by a Force equall to the Force of its Motion: This is plain, For Bodies being of an Unactive Mass of Matter, can acquire no Change or Mutation of their own State, & a Body can no more change its Motion & come to Rest, than change it self from one Figure to another. After the same manner, it can never change its Direction, but will always continue to go forwards in the same Straight Line. But whatever Change is made in a Body must be by some Extrinsecall Agent; & if a Body ever changes its Direction, there must be some Externall Agent to make that change of Direction; & if it were left to its Self, it would always move uniformly forwards, in the same Straight Line.

If a Body move in any Medium, it must necessarily thrust away the parts of that Medium which are in its way: & therefore, since whatever Motion it comunicates to them, it must loose its Self; a Body, that moves in the Air, must continually lose of its Motion: Whereas if there were no Gravity or no Air, a Stone once thrown up would go on in Infinitum, without losing its Motion. The Air then is the only cause why Bodies lose of their Motions when thrown up, & Gravity is the only cause, which brings them to the Earth.

In the Heavens, where the Æther is exceeding Thin & next to nothing, the planets preserve their Motion, without the least Sensible Diminution.

From hence we know the Way, how Motion is comunicated to Bodies; For when a Man holds a Stone in his Hand, the Stone participates of the Motion of his hand, because being in it, it is mov'd with the same Velocity, as the Hand is. Now by this Law of Nature, a Body once put in Motion will always endeavor to go forwards, according to the same Direction; & therefore when the Man draws back his hand without the Stone, the Stone having once a Motion forward will always endeavor to continue in it.

Because all Bodies affect to move in a Straight Line, there must necessarily be some Force to make them move in a Crooked. This Force may be either a String, by which they are tyed to the Centre of the Motion, or some other Centripetall, such as Gravity, which continually presses them towards the Centre.

Suppose a Body put in Motion att A, it will endeavor to move in the same

Straight

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✝ And This is what is call'd Compound Motion: viz. That wch depends on 2 or more Causes, each acting diff.t ways, wch if they act equally, ye Motion goes on in a Straight line just betwn both, If unequally, in a Strait line proportion'd to yeir inequality: As a Body att A driv'n by one force to B, by anothr not so strong to D, it will go in ye Straight line AC (nearer inclin'd to ye Side of ye Strongr Force) till it come to C; & yrby satisfy both its Motions, C lying in ye same plain both as B & D. Plate 3. Fig. 3.

A notable Experiment of ys was seen, By an Arrow shot up perpendicularly fm a Ship att full sail, wch fell down again into ye same place of ye Ship, fm wch it was Sent; tho ye Ship in yt Time had advanced sevll yards. For as Gravity press'd down ye Arrow in one Direction perpendicular to ye place where ye Ship was att first, ye mean while, ye same Wind yt drove ye Ship, gave it anothr parall to ye Ship; ye Arrow yrfore went on in ye Diagonall betwn both Directions, & overtook ye Ship. Thus

See S. Clark's Notes on Rohault part 1, cap. 14. art. 1.

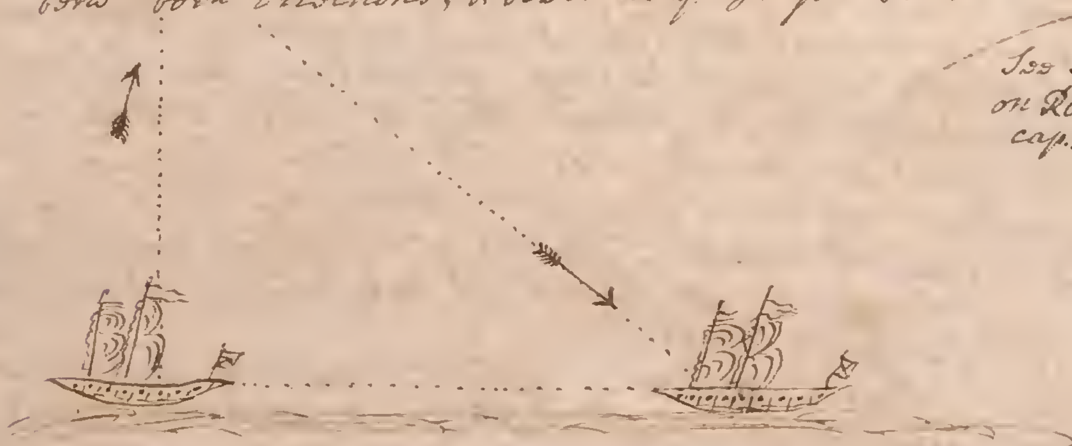


Plate 3, } Fig. 3. } Straight Line AB, but ye Force of Gravity continually pres- (20
sing it tow^d ye Centre, as att ye point A, it will move in ye Diagonal of ye Parallelogram, if you fill it up. ✠

When ye Bomb c is by ye force of ye Powder driv'n out of ye Mortar,
Fig. 6. } it endeavours, by ye 1st Law of Nature, to go on in ye Right Line ce; but Gravity acting upon it in ye Direction eb, makes it move in ye line cb, Diagonal of ye Parallelogram contain'd under ye lines ce eb (i.e. supposing 2 oth^r lines to be drawn ‖ to ye s^d lines ce eb) by a Motion compounded of ye Force pushing tow^ds a, fm c, & yt wch pushes tow^ds b fm e. Then ye Bomb wd, by ye 1st Law of Nature continue to go on tow^ds d in ye line bg, being ye aforesaid Diagonall produc'd; but Gravity acting upon it in ye Direction gf, makes it by a Compound Motion go in ye Digonal bf of ye New Parallelogram contain'd under bg & gf; & so on, till it comes to ye Point h. Now since ye First Impetus & Gravity don't act alternately, but att ye same time all ye while ye Bomb moves; we must suppose ye s^d Digonals, in wch ye Body moves, to be infinitely small & yn all of ym togeth^r will make up ye Curve cbfh, call'd a Parabolick Line, in wch all Projectiles move.

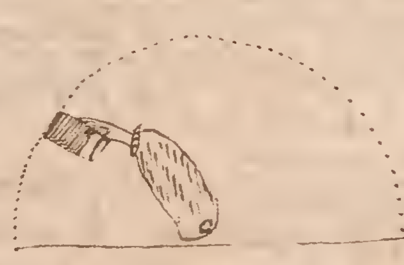
The Swifter a Body moves in a Circle, ye strong^r is its endeavr to move in a Straight line, & ye more ye Thread will be stretch'd by wch it is kept in. The Force, by wch it stretches ye Thread, is call'd ye Centrifugal Force, & it is easily perceiv'd in Slings: & ye Force of ye Thread wch detains it must be just Equall to this Centrifugal Force; but if Gravity or any oth^r Centripetal Force detains ye Body in its Orbitt, ye Centripetal force must be just Equal to ye Centrifugal, yt ye Body may be kept in ye same Circle.

If a Body lies upon a Table, & ye Table be mov'd; att first ye Body will not participate of ye Motion of ye Table, but will seem to go ye Contrary way; as is plain fm a Vessel of water sett upon a Table: But after yt Motion is once comunicated, if you stop ye Table suddenly, ye Body on it will continue in its motion.

If a Round Table parall to ye Horizon be turn'd round an Axis, & a Bullet by ye help of a Thread be made fast to its Centre;
Fig. 5. tho' ye Thread be slack att first, yet after ye Table is turn'd round, ye Bullet att C will recede fm ye Centre, & stretch ye Thread att D: If ye Table be stop'd on a sudden, yet ye Bullet will for some Time continue its Motion. If ye Bullet be not on ye Table, but hangs down by ye Thread in ye posture AB, af-

:ter

♀ By ys Reason, If an open Vessel almost full of wat.^r be turn'd round in a Ring, by a swift motion of ye Hand regularly, not one Drop of ye Water shall fall out; Because ye Water being heavier yn ye Air, has a greater vis Centrifuga, & conseq. keeps farthest off ye Hand & mouth of ye Vessel.



:ter ye Table is turn'd round, ye Thread will not keep its perpendicular position, but will settle its self in ye Position A b; ye Centrifugal Force acting agt ye Force of Gravity, & making ye Body recede as far as it can fm ye Centre of Mocon.

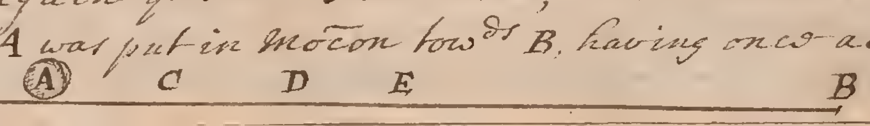
If a Glass Tube be laid or fasten'd to a Table, in wch near ye Centre be
Plate 3, Fig. 5. put a Small Bullet; wn ye Table is turn'd round, we may observe ye Bullet to recede fm ye Centre towds ye Circumference & accelerate its Mocon. Besides ys, It will go agt ye comon Law of Gravity & move upwds, if ye Tube be sett Slanting upwds on ye
Fig. 4. Table, being first fix'd to a peice of Wood represented, & it will stay att ye uppr end of ye Tube beyond H, as long as ye Table is continu'd in its Swift Mocon; but wn yt ceases, it is press'd
♀ down again, by its own Gravity, towds G. The same is observ'd, if we put Globules of Mercury or Water in ye Tube.

If we fill ye Tube wth Water, & put a peice of Cork in ye end of it, wch is next to ye Circumference; we may observe, That after turning ye Table round, ye Cork will go fm ye Circumference towds ye Centre: For ye Water being more Dense, or consisting of a greater Quantity of matter yn ye peice of Cork of ye same Bulk, it will have a greater Vis Centrifuga, or a Strongr Conatus recedendi à Centro, yn ye Cork has; & conseq. ye Cork, wch has much less Force, will be push'd by ye Water, wch has a greater Force, towards ye Centre.

The Second Law of Nature is, "That ye Motion produced, " or ye Mutation of motion, is always proportional to ye mocon " impress'd, wch generates yt mocon. A Double Force will produce a double Quantity of mocon, & a Triple force a Triple, &c And ys mocon will always be acc. to ye Direction of ye Force wch impresses it; and if ye Body was mov'd before ys new mocon arising fm ys new Force, it will eithr encrease its mocon, if it act acc. to ye same Direction, or diminish it, if it act in a contrary direction, or, if it act obliquely, alter its Direction & turn ye Body anothr way.

If a Body be once put in mocon, It ought, by ye 1st Law of nature, always to go on wth ye same Velocity & in ye same Direction: But, if a New Force equall to ye former act again upon it, acc. to ye same direction, Its mocon will be encreas'd doubly; if again ye same Force act, its mocon will be Triple of ye First, &c

Thus if A was put in mocon towds B, having once acquir'd an Impetus



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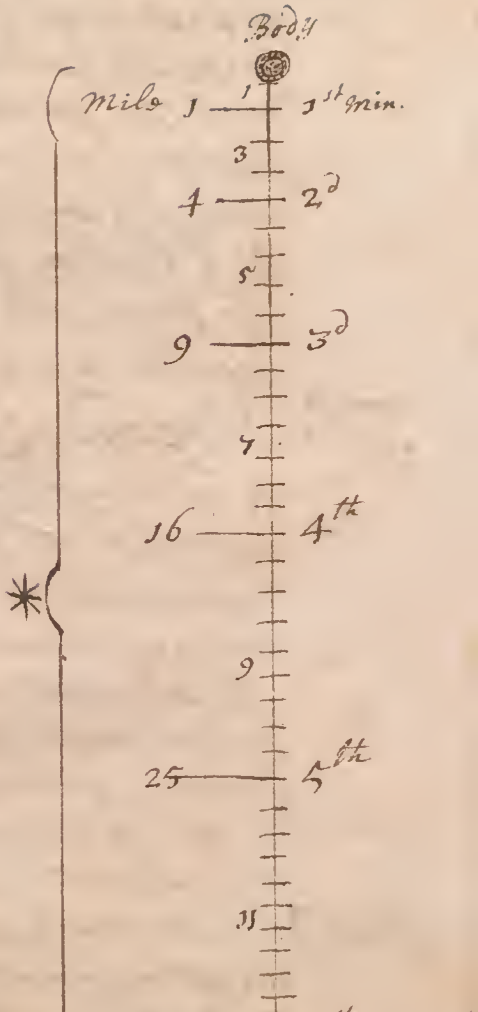

Body
Mile 1
1
1st min.
3
4
2d
5
9
3d
7
16
4th
9
25
5th
11
Miles 36
6th minute
&c

that way, it w^d alway continue in it; But if we sh^d suppose, y^t w^n y^e Body comes to C, y^e same Force acted again upon it, it w^d produce a Moc̄on equall to y^e Form^r, & both y^se putt togeth^r will be Double w^th y^e First. again, w^n y^e Body comes to D, if y^e same Force sh^d act again upon it, There w^d arise a new Quantity of Moc̄on to eith^r of y^e form^r, & y^e whole put togeth^r will be Triple of y^e first moc̄on. If again, w^n y^e Body comes to E, y^e same Force acted upon it, it w^d again produce more moc̄on, w^ch w^d be Equall to y^e First, & so y^e whole Moc̄on arising f^m all y^se actions put togeth^r, w^d be Quadruple w^th y^e First. If y^s Force thus acting imprinted on y^e Bodies equal degrees of Moc̄on att equal Intervals of Time; y^e moc̄on produc'd, & conseq. y^e Velocities w^d be as y^e Times.

W^n a Heavy Body descends, Gravity acting upon it, att first gives it a Moc̄on downw^ds; now if y^e Body sh^d cease for ever after to be Heavy, yet y^e Body will still go on in y^e same Direction, & w^th y^e same Velocity, by y^e 1^st Law. But y^n in y^e 2^d Instant of Time, y^e Body is Heavy, & Gravity continues to act, Therefore it will produce again a Moc̄on equal to y^e Former: just so, if y^e Body ever after sh^d cease to be Heavy, yet it w^d still continue in its Course, w^th y^e 2 acquir'd degrees of Velocity. But y^n Gravity acts y^e 3^d time, after y^e same mann^r as it did at first, & makes a Moc̄on equall to y^e First; after y^e same mann^r y^e Moc̄on y^n will be Triple of y^e first: and y^e 4^th time, Quadruple; & so y^e Moc̄ons will always encrease, as y^e Times.

Plate 3, Fig. 8.

This is y^e Reason, why we find Heavy Bodies in descending, to accelerate y^eir moc̄ons. W^n Bodies fall, the Spaces, thro' w^ch they descend, are as y^e Squares of y^e Times, they take to fall in; alway counting f^m y^e Beginning thus;

If in y^e first minute of Time, a Body fall thro' a certain Space; att y^e End of y^e 2^d minute, it will have descended 4 times y^t Space; att y^e End of y^e 3^d minute, 9 times y^t Space, it went thro' in y^e End of y^e 1^st. So y^t if y^e Times be taken in Arithmetick progression of 1, 2, 3, 4, 5, 6, &c y^e Spaces, thro' w^ch y^e Body will have descended att y^e End of y^se Times, will be as 1, 4, 9, 16, 25, 36 &c. If it be ask'd how far y^e Body moves in y^e 2^d Minute; 'Twill have mov'd just 3 Spaces; For it had mov'd thro' 1 in y^e 1^st: & so likewise in y^e 3^d minute, it will have mov'd thro' 5, For att y^e end of y^e 2^d minute it had mov'd thro' 4, 4–9, y^re remains 5. The Two Rectangular Triangles in Fig. 7, made up of oth^r Rectangul^r Triangles, rep^rsent y^e Spaces gone thro' in a Determinate Time, each single Triangle one Space;

*

Fig. 8.

as

Y

As for Example, In ye Upper Figure of ye 2; If we suppose a (23
Plate 3.) Falling Body to sett out att ye rate of one Mile in one minute,
Fig. 7.) let ye Numbr 1 & ye perpendicular of ye little Triangle attop
express ye 1st Time or Minute; & ye sd numbr 1 & ye Base of
ye sd little Triangle express ye Velocity, wch always is as
ye Times; & let ye whole Triangle express one Mile, yt ye
Body fell in ye 1st Minute: Then if you considr, yt ye
Body having fall'n 4 minutes, ye Line expressing ye Times
must be ye Perpendiculr of ye great Triangle, wch perpendicr
is 4 times greater yn yt of ye little upper Triangle; like-
wise ye Line expressing ye Velocity must be ye Base of ye gr
Triangle, wch Base is 4 times greatr yn ye Base of ye little Tri-
angle; and ye whole Triangle will be ye Sum of ye Spaces or
Miles gone thro' in 4 minutes: wch will appear, by dividing
into little Triangles equal to ye 1st. A Sight of ye Figure
will easily teach how to know ye Miles, yt ye Body has fall'n
thro' in any Numbr of minutes or Times.

If a Body, as A, lies upon an Inclin'd plain, it endeavors to descend
Fig. 10.} perpendicularly, but ye Plane hindring it, wth part of its bt
it will press upon ye plain, & wth ye Rest descend, as it can,
along ye plain; but it will not accelerate its Motion so fast,
as if it did all along descend perpendicularly: Thus in Falling
fm B to C it takes longr Time, yn if it had gone directly fm
B to D in ye perpendiculr; so yt at ye point C it will have
as much Velocity in falling fm B to C, as att ye point D it
has in falling fm B to D. The less ye plain is inclin'd to ye
Horizon, or ye nearer it comes to ye perpendiculr ye
faster it will accelerate its Motion.

Thus it will sooner fall fm B to G, yn fm B to C; & sooner fm B to E, yn
Fig. 11.} fm B to F; but in falling fm ye same point B to ye points D, E, F,
G, C, ye degrees of Velocity acquir'd are equall, tho' they be ac-
quir'd in unequall Times. (v.g.) Suppose BC 3 times longer yn
BD ye Body will go fm B to D in ye 3d part of ye Time, yt it
goes in ye plain BC fm B to C; but ye Velocity acquir'd in
ye descending fm B to D is ye same yt is acquir'd in ye
descending fm B to C; & therefore it will accelerate its Mo-
tion in ye line BD 3 times faster yn in ye line BC.

If a Body, in falling fm B to D, acquire any degree of Velocity, & wth
Fig. 12.} yt Velocity be turn'd upwds; It will ascend just to ye same
height, fm wch it fell, & Gravity acting upon it will lessen con-
:tinually

\# To Find out ye proportion of Velocitys betwn ye Great-er & Less Strings, or Radii, of a Pendulu.

Having ye Velocity of ye greater Radius giv'n, Multiply ye Square of yt Velocity by ye Length of ye greater Radius; yn Divide ye Product by ye Length of ye lesser Radius, & ye Square Root of ye Quotient will give you ye Velocity of ye lesser Radius. Q. E. I.

Or, having ye Velocity of ye lesser Radius giv'n, Multiply ye Square of yt Velocity by ye Length of ye lesser Radius; yn dividing ye Product by ye Length of ye greater Radius, & ye Square-Root of ye Quotient will be ye Velocity of ye greater Radius. Q. E. I.

$$>R. = 8 \,.\; V. = 4 \,. \quad \left\{ \begin{array}{l} V.q. = 16 \times 8 = >R. \\ (<R.\,2)\;128\;(64,\; q.r.\; 8 = V. <R. \end{array} \right.$$

$$<R. = 2 \,.\; V = 8 \,. \quad \left\{ \begin{array}{l} V.q. = 64 \times 2 = <R. \\ (>R.\,8)\;120\;(16,\; q.r.\; 4 = V. >R. \end{array} \right.$$

Plate 3. } Fig. 12. } tinually its Velocity in y^e same pportion as it encreas'd it be=
fore in descending, & after it has come to y^e point B, it will begin imediately to descend again. after y^e same mann^r, if having fallen along BD, it be turn'd up in y^e Inclining plain BC, w^th y^t velocity it acquir'd in descending, it will just go to y^e same height, f^m w^ch it fell.

If y^e Body B hanging by y^e String AB down towards E, be mov'd f^m B to D, & f^m y^nce lett fall, it will continually accelerate its Mocon, 'till it comes to y^e point B or E, & y^n w^th all its force it will go in y^e arch BC to y^e point C of y^e same height w^th y^e point D f^m w^ch it fell; & y^n att y^e point C it will descend to B, & y^re it will have y^e same Velocity as it had before att B, w^th w^ch it will ascend to D, & so make Vibracons continually. The Body so hung is call'd a Pendulum. Fig. 14. }

Suppose a Circle, whose plane is ⊥ to y^e Horizon, in w^ch were drawn BD, BE, BF f^m y^e lowermost point B; A Body will descend in y^e same time along y^e line BD f^m D to B, as it will along y^e line EB f^m E to B, or along y^e line FB f^m F to B. The Reason is this; Tho' y^e line FB is longer y^n y^e line BD, yet it is also more ⊥ & less Inclin'd to th' Horizon, y^n BD is, & Conseq. y^e Body will accelerate its Mocon faster upon y^e line BF, y^n upon y^e line BD; & y^e Velocity acquir'd in falling f^m F to B will have y^e same pportion to y^t acquir'd in falling f^m D to B, as y^e line FB has to y^e line BD. Fig. 9. }

Because small arches do not differ much eith^r in Declivity or Length f^m y^eir Chords; Bodies will descend very nearly in y^e same time in y^e arches of Circles, as they will do in y^e Chords of y^se arches: But Bodies descend in y^e same Time thrô all y^e Chords, wheth^r they be greater or less; & by consequence y^e Vibracons of y^e same Pendulum, wheth^r it runs out in a greater arch or Less, are all perform'd in y^e same Time.

Lett A fall f^m 8, & B f^m 4; y^e Velocity with w^ch A will be mov'd, being so much greater y^n y^t of B, they will both meet exactly att y^e point C. — The shorter y^e Strings are, y^e quicker y^e Vibracons; because y^e Strings are as y^e Half-Diameter of y^e Circle; & so y^e Less y^e String is y^e less is y^e Circle, & conseq. y^e Lesser y^e Circle is, y^e Quick^r will y^e Body move round it. Fig. 16. }

The Third Law of Nature is, "That action & Reaction are always equal & Contrary i.e. The actions of Bodies one upon anoth^r are always equal, & y^e Force impress'd alway directed tow^d y^e Contrary parts; so y^t y^e Mutations of Mocon, w^ch y^se actions produce are always Equal.

This Law may be illustrated by severall Examples;

First, If y^e Body A moving tow^ds C meet w^th B att Rest; w^tever Mocon

D ——— (A) — (B) ——— C

The Body B getts by y^e Impulse,

so

a

so much precisely will ye Body A lose (v.g.) If ye Body A have 12° of Motion, & after ye Impulse B have 5, yn A will have but 7 remaining; & therefore yre will be Equall mutations of Motion in Both, & ye Effect will be ye same, as if a Force Equivalent to 5° of Motion acted upon A towds D contrary to its former Motion, & anothr equall to yt acted upon B impelling it towds C; & Universally, wn one Body hits another, ye Stroke or Blow is equally recd in Both, & its always proportionable to ye Motion lost in ye Percutient Body.

If an Horse draws a Stone, wch is ty'd to a String; The Force, by wch ye Horse is pull'd back to ye Stone, is equal to ye Force, by wch ye Stone is drawn towd ye Horse: For ye Rope being equally stretch'd, by ye same powr, wch it has to contract it self, will pull equally ye Stone towds ye Horse, & ye Horse towds ye Stone; and therefore ye Force of Attraction in ye Horse, & in ye Stone, are Equall. But seeing ye Horses strength is so great, assisted by ye ground on wch he stands, yt he can resist ye attraction of ye Rope, The Horse will not in ye least yeild to ye Attraction, nor be pull'd out of his place; But ye Stone, wch has not so great a Force of Resisting, will be drawn towds ye Horse.

If ye Loadstone attract Iron, ye Iron will likewise equally attract ye Loadstone; As may be seen, If you hold Iron fix'd, & let ye Loadstone Swim on Cork in ye Water, or Hang in a Scale.

The same Thing is True in othr attractions:

Suppose 2 Boats A & B floating on ye Water, & a man in one of ym (v.g.) A, by ye help of a Rope, pulls ye Boat B towds him; By ys Attraction, not only ye Boat B comes to A, but also ye Boat A will be equally drawn to B, so yt ye Quantity of Motion will be equall in Both: And if ye Boats be of ye same Weight & bigness, they will meet att E ye mid-way betwn A & B. (E.g.) Suppose B to be 10 times greater yn A, yn B will have 10 times less Velocity yn A, & ye Bodies will meet not att E but D, so yt GD will be 10 times longr yn FD. If B is 1000 times greater yn A, they will meet at ye point D, wch will be such, yt GD will be 1000 times greater yn FD; & conseq. it ought to have 1000 times less Velocity, so as to make ye Momentum equall in both: But if B be vastly greater yn A, its Velocity will be vastly less, & altogr Insensible.

(Plate 3, Fig. 18.)

If a Man in A, by ye help of a Pole thrust ye Boat B fm him towds H; by yt Thrusting ye Boat B forwd, ye Boat A will be thrust backwd towds

b

tow^ds K, so y^t y^re will be Equall Quantities of Mocon in Both (26)
tow^ds Contrary parts; & therefore if B is 10 times greater y^n A, B will move tow^ds H w^th 10 times less Velocity, y^n A w^ch moves y^e contrary way tow^ds K, so y^t y^e Quantities of Mocon in both are equal. If B is imensly bigg^r y^n A, its Velocity will be less y^n A's in y^e same proportion; & Conseq. it will be altog^r insensible in respect of A's, & may be reputed as None. And therefore w^n a Man in a Boat thrusts y^e Earth or Shore fm him, y^e Boat by his thrusting will recede fm y^e Shore; for y^e Shore may be consid.^d as a prodigious great Body in resp^t of y^e Boat, & conseq. its Velocity will vanish, & be Equivalent to Nothing.

Plate 3. Fig. 17.

When a Boat is Row'd w^th oars, y^e Water by y^e Mocon of y^e Oars is repell'd back to C, & y^refore will React upon y^e Oars, & give to y^e Boat, to w^ch they're fix'd, a Mocon tow^ds D. And 'tis only upon y^s acc^t, y^t y^e Boat advances forw^d; for if y^re was no Reaction, & y^e Water by being thrust back did not give y^e Boat a Mocon forw^d, It must stand still, because y^re w^d be no Cause for its Mocon: But now, since y^e water Reacts upon y^e Oars, it comunicates by its Reaction as much Mocon to y^e Oar forw^d, as y^e Oar did to y^e Water backward.

Since Swiming is nothing, but Rowing w^th Feet & Hands; we may easily understand y^e Reason, why by y^s Mocon both of Hands & Feet we advance forw^d. For w^n y^e water is thrust backw^d, it will by Reaction repell y^e Swimer forw^d; likewise, w^n by y^e Mocon of Both Hands, we thrust y^e Water down, it by Reaction will force us upwards.

The same thing is to be apply'd to y^e Flying of Birds, w^ch is nothing but Swimming in y^e air.

The Generall Rule, y^t all Bodies observe in their Mocon, is This,
"The Sum of y^eir Mocons tow^ds y^e same p^t, (w^ch is known, by taking y^e Sums, w^n y^e Bodies move y^e same way; & y^e difference, w^n they move contrary ways) "remains always "y^e same before & after y^eir mutuall Impulse.

Bodys, w^ch have no Elasticity, move togeth^r, after y^eir congress, w^thout any Separacon, tow^ds y^t Side, where y^re was most Mocon: And because y^e Sum of y^eir Mocons is always y^e same before & after percussion; if we take y^e Sum & divide it by y^e Quantity of Matt^r or Weight of y^e Bodies, y^e Quotient will give y^eir Comon Celerity, w^th w^ch they will move after Conjunction.

Suppose 2 Bodys A & B equall, each of 5^lt w^t, of w^ch B is at rest, & A moves tow^ds it w^th 4° of Velocity; Because B has no Mocon,
y^e

c

* This must be done by Bodys wch have no Elasticity; as
2 Equall clay Balls hung up by a String & lett down
fm an Equall height, meeting att ye $\perp$ both Rest, so
yt yeir Mocon seems to be lost: If it be not (as is
objected by some) yt ye Comon mocon of ye whole Bodys
is yn chang'd into a proper mocon of ye pts in each
Body, wch tremble yreupon so long, till they may
have comunicated yeir whole quantity of mocon
to ye ambient air, so yt none be lost acc. to Cartesius.

Phil. Burg. p. 1. Tr. 2 diss. 1. c. 4

S. Clarke Annot. ad Roh. p. 1 c. 15. art. 2.

Sum of y^e^ir Motions will be 4×5 or 20, w^ch^ being divided (27)
by y^e^ Sum of y^e^ir W^t^, viz. 10, y^e^ Quotient will be 2, w^ch^ is y^e^ir
comon Velocity after Conjunction. So y^t^ if one Body move
directly upon anoth^r^ equall to it w^ch^ is att Rest; after y^e^ir
Conjunction they will go both togeth^r^ w^th^ half y^e^ form^r^ Velocity.

If A & B were equall, & B was mov'd acc. to y^e^ same direction w^th^ A, but w^th^ less Velocity; after y^e^ir Conjunction they will both go togeth^r^ w^th^ half y^e^ Sum of y^e^ir Velocities. Suppose A's velocity 8°, & B's 6°, after Impulse, y^e^ Velocity of each will be 7. If B moves by a Contrary direction, w^th^ less Mocon y^n^ A has; y^n^, if y^e^ Bodys be equal, they'll move togeth^r^ w^th^ half y^e^ Difference, after meeting. But universally, y^e^ir Velocity is determin'd by taking y^e^ difference of y^e^ir Mocons (w^ch^ is y^e^ Sum of y^e^ir Mocons tow^ds^ y^e^ same direction) divided by y^e^ Sum of y^e^ir Bodies.

Suppose A 10^tt^ & B 6^tt^; lett A's Velocity be 5° & B's 3°; y^e^ Difference of y^e^ir Mocons is 32, w^ch^ being divided by 16 y^e^ Sum of y^e^ Bodies, y^e^ Quotient 2 is y^e^ir comon Velocity after meeting.

But, If A & B moving Contrary ways have equall Quantities of motion, after Concourse, they'll both Rest; for y^n^ y^e^ difference of y^e^ir Mocons being nothing, after meeting they can have no Mocon. (E.g.) Suppose A 10^tt^ & B 8^tt^, let A's velocity be 4° & B's 5°; in y^t^ case y^e^ mocon in each will be 40°, & y^ere^ being no difference of mocon, y^e^ 2 equall & contrary forces, acting one upon anoth^r^, will destroy one anoth^rs^ mocon.

* And therefore Cartesius's Law of Mocon is False, by w^ch^ he s^d^ That y^re^ was always y^e^ same Quantity of Mocon p^r^serv'd in y^e^ [World.

If y^re^ were no Elasticity, The former Laws w^d^ serve for all Bodies; but by reason y^re^ are few Bodies, but w^t^ are Elastick; the Rules of comon Mocon are sometimes very diff^t^ f^m^ y^se^ already giv'n: For by y^e^ Force of Elasticity of Bodys, sometimes they move after Percussion & acc. to y^e^ same Direction, & sometimes they go in Contrary direction.

That we may Explain y^e^ cause of Resilition & Separacon of Bodies, We may Illustrate it by an Example thus: Let AB rep^r^sent a Silken thread or Cats-gutt, stretch'd & strongly extended on y^e^ Table, by y^e^ help of 2 Nails; If y^e^ Thread be tak'n by y^e^ middle part & mov'd out of its place, so y^t^ y^e^ point D comes to C, & y^e^ thread lie in y^e^ position ACB; If it be y^n^ left to it self, it will ~~will~~ imediately w^th^ Force go to restore it self to its former position. Now, by y^e^ continuall acting of y^e^ this Elastick Force, by w^ch^ it endeavo^rs^ to restore it self, it will

Plate 3, Fig. 15.

con=

d

continually encrease its Velocity, just as heavy Bodies do; (28

Plate 3. Fig. 15. & wn it comes to ye point D, it will have a Force to go on forward equall to yt, by wch it was forc'd out of its position; By wch mocon it will still go on, 'till it comes into ye position AEB, & yn it will restore it self again, & perform vibracons just as in a Pendulum. Now let us Suppose a Body D to run upon ye thread AB, ye Thread by ys Force will be put out of its position AB into ye position AFB, where it will quickly stop ye Mocon of ye Body D. Now ye mocon of D being destroy'd, ye Thread by its Elastick force endeavouring to restore it self, will return to its former position, wth ye same Force, by wch it was put out of it, & will bring back ye Body D again wth it; & wn it comes to ye position ADB, 'twill have ye same force to go forwd towds E, as it had, wn it was put out of its position First: It had yn all ye Force of ye Body D impress'd on it, for all yt Force was spent in ye bending ye Thread, therefore it will restore it self wth all yt Force, & conseq. drive ye Body D backwds wth ye same force, wth wch it came upon it. The Body D having yn once gott an Impulse backwds equal to wt it had att first forwd, will, by ye 1st Law of Nature, always continue in yt Mocon, & yrefore will be reflected wth ye same Velocity it had att first forward. If ye thread dos not restore it self wth ye same Force, by wch it was bended ye Body will not be reflected wth a Velocity equal to wt it had att first.

If ye Body runs sloaping upon ye Thread, ye Reflexion will be Oblique; so yt ye Incident angle B be equal to ye Reflected C.

Fig. 17. If instead of ye Thread yre was plac'd an Elastick Body; & suppose its Surface bended in, by ye force of ye Stroak, fm ye position ADB into ye position ACB; As soon as ever ye force of ye stroak ceases, ye Surface ACB, by ye force of Elasticity, will be restor'd into its formr position, & by all yt force, by wch it restores its self, it will act upon ye Body F & make it move back again. Now if ye Body be a perfect Elastick Body, 'twill restore it self wth ye same force wth wch it was compress'd, & yrefore 'twill make ye Body F recede fm it, wth ye same Velocity, wth wch it att first advanc'd towards it.

Now yt all Reflecting Bodies, as Glass, Ivory, Marble, &c are Elastick, may be easily concluded fm ye Sound & Tinkling wch they give, wn yey are struck; Just as in a Silken or Lute String, wn stretch'd & struck, they produce an Undulacon in ye air, caus'd by freqt vibracons, after ye same mannr, but not so lasting.

But

e

× As Suppose A a Body in Mocōn strikes upon B anothr Body att Rest, wth 10° of Velocity; B will not only move wth 5 of yose degrees, but being flatend, will also by its Elasticity React upon A wth ye same Force, by wch it was Struck viz 5° more; wch Force being equall to ye Mocon ~~of~~ left in A & in Contrary direction, will quite destroy it. So yt A shall Stop. But A's Elasticity shall act upon B wth 5° still, So yt B shall go on wth 10°, all ye Velocity of A.

† Suppose A comes wth 10° of V. upon B moving already in ye same direction wth 8° of V. ye Force of yeir Stroak being 2 (ye difference of yeir Absolute Velocities) acts contrary to A, so yt A loses 2 & becomes but 8; but wth B, wch gets 2 & becomes 10.

But it may be more easily prov'd fm ye Concourse of Glass or Marble Spheres: for if you Tinge one wth any Colr, & let ye othr fall upon it The percutient Bodie will have a greater portion of its Surface ting'd yn yt in wch it Ordinarily touches; & yrefore by ye Shoak it must be somewt flatten'd, tho afterwd it restores it self again.

Bodies, yt are perfectly Elastick, recede fm one anothr after Impulse, wth ye same Velocity, they approach'd each othr with, before they Struck. or, wch is ye Same, Their Relative Velocity, before & aftr yr mutual percussion, abides ye Same. The Reason's This: Bodys recede fm each other only by yeir Elastick Force, by wch they restore ym selves to yeir First Figure; But yt Force is Equal to ye Force of ye Shoak, by wch ye Figures are chang'd, & ye Force of ye Shoak is allways as ye Velocitys, by wch they approach'd one anothr; Therefore ye same Force will make ym recede fm each other.

If ye Bodies move towd Contrary Directions, ye Force of ye Shoak is as ye Relative Velocity, wch is Equal to ye Sum of both yr Velocities.

But if they go on in ye Same Direction, ye Force of ye Shoak, wch is Still as yr Relative Velocity, will be likewise as ye difference of yr absolute Velocities. For ye Relative Velocities of Bodies are always as ye Sum or Difference of yeir reall velocities, acc. as Bodies move in Contrary or ye Same Directions. Fm ys property of perfectly Elastick Bodies & ye Univ.l Law of Moc̃on, That ye Sum of yeir moc̃ons towds ye same Direction always remains ye Same; It is Easy to determine ye Velocities of each of ye Elastick Bodies, after percussion.

The Rules wch They Observe, are yse Following:

†1. If a perfectly Elastick Body comes upon anothr equal to it, & att Rest; after percussion, ye Percutient will stand still, & ye othr go forwd wth all ye velocity of ye percutient.

2. If 2 Equal Bodies move Contrary; after meeting they will both reflect & change yeir Velocities one wth ye othr.

†3. If 2 Equall Bodies move acc. to ye Same Direction; aftr concourse, they will change yeir Velocities one wth anothr, & ye Antecedent will have ye Velocity of ye Consequent, & ye Conseqt yt of ye Antecedt.

4. If a Little Elastick Body comes upon a greater, wch is at Rest; The Impingent Body will be reflected, & ye othr will go forwd wth a moc̃on equall to both ye moc̃on of ye Impingent forwd, before ye Impulse, & its moc̃on backwds, after.

5. If ye Greater Body comes upon a Less; They will Both move after Reflection, in ye Same Direction.

Those, who Understand Algebra, may calculate ye Velocitys of all sorts of Elastick Bodies, after yr mutual Congress.

Hyd=

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*Mons.r Ozanam's Definition of a Fluid & Liquid.

A Fluid is a Body y.t is Easily pass'd thrô, & whose Sepa=
rated parts joyn again Imediately; as Air, Flame, Wa=
ter, Oyl, Mercury, & oth.r Liquo.rs. A Liquid is a
Fluid, w.ch being in a Sufficient Quantity, flows contin=
ually & Spreads it Self below y.e Air, 'till its upp.r
Surface is Levell, or in an Horizontall Position.

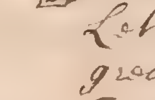
Hydrostaticks.

Definitions. * A Fluid is a Body, whose parts yeild to any Force impress'd, & by yeilding are easily putt in Mocon.

A Solid is a Body whose parts are so connected, as not to be divided without a Given & Determinate Force. By Solidity we don't mean yt property of Bodies, by wch they Resist penetracon; but yt Coharence of ye pts by wch they Endeavor not to be Separated.

Gravity is That Force, wch pushes Bodies downwards.

One Body is said to be Specifically or Intensly heavier yn another, wn it has more Weight & ye Same Bulk, or as much wt & a less Bulk. If A were an Inch of Wood & B an Inch of Lead,



if B weigh 4 ounces & A 1 ounce; B will have 4 times more Gravity viz. Specifick, yn A.

Let A be an Ounce of Wood, & D an ounce of Lead; If A be 4 times greater yn D, D will have 4 times ye Specifick Gravity of A; For yre is a Reciprocal proportion between ye Bulk & Specifick Gravity of Æquiponderous Bodies.

Proposition 1. Both ye Superiour & Inferiour pts of any Heavy Body are Heavy; & ye Superior press ye Inferior by yeir Gravity.

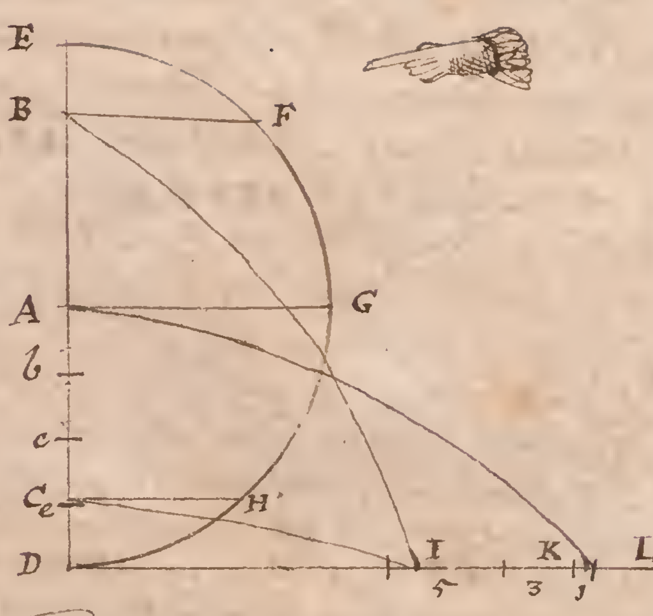
Let a Fluid be put in ye Vessel ABCD, I say all its parts are heavy

Plate 3. Fig. 19. & yt ye Super pts AEFD press ye Inferior. For Since ye whole Fluid is Heavy by ye Hypothesis, & ye pts partake of ye Nature of ye whole, it appears yt all ye pts are Heavy; & yrfore Since Gravity is yt Force, wch pushes Bodies downwds, it appears also yt ys Force is exercis'd on ye Inferior pts of ye Fluid, wch are Therefore press'd by ye Superiour. Q. E. D.

Coroll. Fm Hence it follows, That ye pressure on any part of ye Fluid is always acc. to ye Height of ye Incumbent Fluid. For ye Superficies EF is press'd by AEFD, & ye Superficies GH by AGHD, whose Weights or pressures are as AE & AG.

Experiment. Take a Glass Bubble, & having by heat expell'd some of ye air out of it, imediately seal it Hermetically; wn 'tis Cold tye it to a Balance, & add so much wt to it, as will make it sink, Then putt wts into ye other Scale, to keep it fm sinking, Then break off a peice of ye long neck of ye Bubble, wthin ye Water, so yt ye Water may run into it; and you will find yt ye wt in ye other Scale will not keep ye Balance even: Whereas, if

N. B. That ye Velocity
of Liquors spouting out of
a Barrell is diminish'd acc.
p.22 to ye Squares, just as Heavy
Bodys descending accelerate
their motion. E. g. Suppose
ye Liquor as it sinks in ye
Barrell fm A to b to lose
one Inch of its Velocity
mark'd on ye Plain DL;
then as it sinks fm b to c, it
will lose 3 inches more; as
fm c to e, it will lose 5 more:
adding wch defects to ye former
Summ still, they will produce ye
Square Numbers fm 1, 4, 9 &c



if ye Water wthin ye Bubble did not weigh, ye Whole wd still (31
be kept in Æquilibrio, because acc. to yt Supposition yre is no addition of Matter yt weighs. Hence 'tis plain yt Water weighs in water.

ad Coroll. 1. On ys Principle are founded all Water-Works & Fountains according to ye Height of yeir Reservatories, so high will ye Water rise. v.g. If ye Reservatory be 20 foot, ye Spouted water will rise 20 foot, allowing for ye Resistance of ye air.

If you Tap a Barrell full of water att sevll places, ye Highest will spout out ye least way, because its height fm ye Surface is ye least, & conseq. ye Pressure is ye least; That wch is Lowest will press & fly farthest, because farther fm ye Surface, & yrefore ye greater pressure upon it. But This must be understood, If ye Barrell be a Sufficient height above ye plain, on wch it Spouts, as

Plate 3, Fig. 25.

For, if ye Barrell shd lye upon an Horizontal plain, The Liquor, wch comes out att ye middle of ye Vessel, wou'd spout farthest; Because tho' ye Liquor comes out at Bottom wth ye greatest Velocity, ye Plain wd intercept it att a less Distance fm the Barrell, yn if ye Barrell was higher. In such a Case, The liquor Spouting fm an Hole as near ye Levell of ye Surface of ye Liquor in ye Barrell, as ye Distance of ye Lowest hole fm ye Levell of ye plain on wch it is to Spout, will fall on ye Plain in ye same Place, as ye Liquor yt comes out at ye lowest hole. [in fig.]

To Know Exactly how far ye Liquor will Spout out of a Barrell peirc'd in any determinate place, make ye following Construction.

☞ **DL** represents ye Plain, on wch ye Liquor is to Spout; **ED**, perpendicular to it, is ye Distance fm ye Top of ye liquor in ye Barrell to ye Levell of **DL**; Fm ye Centre **A**, middle of **ED**, draw ye Semicircle **EFGHD**; Then mark on ye line **ED** ye distance (fm ye Surface of ye Liquor) at wch you wou'd Tap ye Barrell, e.g. ye point **B**, **A**, or **C**; fm any of yse points Raise a ⊥ till it cuts ye Circumference **EGD**, as att **F**, **G** or **H**; Sett off any of yse lines, as **AG**, twice upon ye line **DL**, fm **D** towds **L**, as **DK**; And yt will be ye place on ye plain, where ye Liquor will fall Spouting fm ye Curve **AK**. If yrefore **B** & **C** be equally distant fm **E** & **D**, **BF** will be equall to **CH**, & yse equall lines being sett off twice upon **DL**, **I** will be ye place, where ye Spouted water will fall on ye Plain **DL** Whether ye Vessel be Tap'd att **B** or att **C**; forasmuch as ye Spout **CI** has more Velocity yn ye Spout **BI**, So much is **CI** sooner intercepted by ye plain, yn **BI**.

If a Spout of a Barrell be turn'd upwards, ye water will rise as high out of it, as ye height of ye Water in ye Barrell, viz. to A; & as ye Water sinks, so will ye Spouted water wthout sink too.

Fig. 26.

Prop.

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Prop. 2. In any Fluid, as ABCD, not only ye parts are press'd (32
Plate. 3.} downwds, but yre is also a Laterall pressure, & a pressure fm all pts
Fig. 19.} For Wn a Fluid is press'd fm all sides, it endeavors to recede fm yt pressure; fm wnce That Force of receding will press all circumjacent
Fig 22.} Bodies, whether Fluid or Hard. v.g. Lett a Drop of water, as @ be press'd by ye Finger D upon ye plain BC; It will not only press ye plain BC, but also endeavor to recede towd ye parts B, & C; & if yre be any Body, as f, wch hinders its Mocon, it appears, yt That Body is press'd wth all yt Force, by wch it endeavors to recede towd B.

After ye same Manner in ye Fluid ABCD, lett any part be assign'd, as
Fig. 20.} E (wch by ye foregoing Propn) is press'd by ye upper pt G, & endeavor to recede towards ye pts F & K; Therefore it must needs be yt it presses F & K, wth all yt Force, by wch it endeavors to recede towd ye pts Q.E.D.

Coroll. Hence ye Lateral pressure is acc. to ye Height of ye Incubent Fluid.

Schol. Hence is easily understood, why Flasks well stop't & only full of air being lett down into ye Sea (by some weight tied to ym) are broken; viz. By ye great weight of ye Incumbent water, wch neither ye soundness of ye Flask, nor ye Included air is able to Resist.

Experimt. If you imerge a Glass Tube in water, & stop ye open end
Fig. 24.} wth yr finger to Hinder ye water fm falling out of it again; & imediately take ye Tube out of water, & putt it a pretty way into a Vessel of Oil, so yt ye uppermost Surface of ye Water may be below ye Surface of ye Oil; The Oil will force ye Water up: For ye Oil at EF being more press'd by ye Columns of Oil G & H, yn it is by ye Incumbent water at M, will be forced upwds, & it will make ye Water att M to ascend, 'till ye Fluid in ye Tube presses as much on ye Surface M, as ye Oil att GH does on ye Surface EF. Now because Water is heavier yn Oil, ye Water in ye Tube will not rise so high as ye Surface of ye Oil, for, ye water being heavier, a Column of a less Height will ~~a~~ press as much on M, as ye Columns G,H press on E,F. Hence we see yt a lighter Fluid may press on one yt is Heavier.

Prop. 3. If all ye parts FEK of an Homogeneous Fluid, as ABCD, wch
Fig. 20} lie under ye same Horizontal plain, are equally press'd; fm such a Pressure yre arises no Mocon.

For wn ye Pressure is equall on all ye parts, they will all press each other with an Equall force, wherefore no one part will yeild to anothr, But ye Under Fluid powerfully assisted by ye Bottom of ye Vessel, resists yeir Pressure downwds; Therefore fm such a pressure, yre arises no mocon. Q. E. D.

Cor: Hence also ye parts of an Homogeneous Fluid are att Rest, & not moved by any Intestine Mocon; For since all ye parts equally resist

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sist, one part will not yeild to anoth^r; & yrefore they arent 33
mov'd: Contrary to Cartesius's opinion, who held yt Fluidity consists in a Continuall & various mocon of ye Parts.

Prop. 4. If any part, as E, of ye Fluid ABCD is more press'd yn ye Rest, It will drive out both ye pts under it & yose à Latere, fm yeir places. For if ye parts of a Fluid easily yeild to any Force impress'd (by Def. 1.) It appears yt ye pts FGK wch are next to E, will give place to it pressing wth a greater force; Fm whence E flows into yeir places. Q.E.D.

(Plate 3, Fig. 20.)

Experimt. Fill a Tube wth Oil, & imerge ye Botto a little way into a Vessel of Water (ye Top of ye Tube being kept stop'd wth yor finger) so yt it stand a good distance above ye Surface, as att n; then ye Water att m, being press'd by a high Column, will be more strongly press'd by ye Incumbent Oil, yn E & F are by ye Incumbent water; & Conseq. it will (after yor finger's remov'd fm ye Top of ye Tube) thrust ye Water att E & F out of its place, to give ye Oil liberty to descend: and yn you will see ye Oil come out of ye Tube by drops, & yn mixing wth ye water, it will ascend & swim on ye Surface.

(Fig. 23.)

Prop. 5. If ye part E of ye Fluid ABCD be less press'd, yn ye Rest, ye parts next to it, as FGK, being more press'd will thrust it away & possess its Room, & ye pt E will rise, untill ye pressure of ye parts next to it be equall to its own pressure. For since ye pt E being less press'd cannot resist ye Rest pressing stronger, it will yeild to ym (by Def. 1.) & yt always, 'till it comes to such a place where ye pressure of ye Parts next to it be equall to its own pressure, where (by Prop. 3.) it will Rest. But if it be a Fluid, & it happens not to rest under ye Superficies, yn it will spread it self all over ye uppr Superficies.

(Fig. 20.)

Cor. Hence, if ye pts of a Fluid are in Æquilibrio, they are Equally press'd under ye same Horizontal Plains.

Exper. Take a Tube, & fill it a little way wth Oil, & stop it as before; Then Oil will still remain in ye Tube (being kept yre by ye Pressure of ye Air:) Imediately Imerge ye Tube in water a good way below ye Surface of ye Oil, yn take off yor Thumb, & you will imediately see ye Water thrust up ye Oil above ye Surface.
The Reason's This: Suppose ye Oil in ye Tube only to reach to e, yn ye Surface of ye Watr att g being only press'd wth ye Column of Oil eg, & ye Watr att S & R being press'd wth highr Columns dS & bR; ye Parts of ye Fluid att S & R being more pressed, yn ye Part g, will thrust g out of its place, & make it ascend in

(Fig. 24.)

Plate 3,} in ye Tube & press up ye Oil; wch will continually Rise, (34
Fig. 24.} till (wn it is at a) ye oil & water in ye Tube press as much upon g, as ye Columns dS & bR do upon SR. Now because ye oil is higher yn ye Water, ye Column of Oil presses as much on ye
Fig. 23.} Surface M as a Column of Water wd do, & must be higher yn yt Column of Water; and Therefore ye Oil will rise highr yn ye Surface of ye Water, to a.

If we Try ys Experimt wth Water in Oil (as it is prop. 2) ye Watr in ye Tube will be below ye Surface of ye Oil, so much as it is Specifically Heavier

The Same will hold, If a Solid press upon ye Fluid; nay, ev'n Lead may be made Thus to Swim, after ye following manner:

Exp. Take a Cylindriacall Glass open att both Ends & round att ye Bottom, Then holding a Smooth wt of Lead close to ye ground-End of ye Glass (wth wet or Oil-d Leathr upon ye lead, yt no Water may gett into ye Glass, betwixt it & ye Lead:) Plunge ye whole in ye water till ye Depth of ye Lead in ye Watr be abt 12 times its thickness or something more; & ye Water will keep ye Lead fm Sinking, pushing agt it by a force equall to ye Excess, by wch ye water (wch is by yt vessel hindred fm pressing imediately under ye Lead) exceeds ye wt of ye Lead: But if ye Vessel be rais'd till ye Lead be but 9 or 10 times its thickness below ye upper Surface of ye Water; ye Lead will leave ye Glass & Sink down, moving, as it leaves ye Glass, wth a force equall to th' Excess, by wch it Exceeds ye Water yt it keeps out fm pressing imediately under ye Lead; Because a pillar of Water of ye Diameter of ye Lead ought to be almost 12 times its thickness, to be equall to it in wt.

Thus will any Metall be made to Swim, if they are Sunk into ye Water, something deeper yn as many times yeir Thickness, as they are Specifically heavier yn water; always supposing ye Glass to hindr the Water fm coming in to Sink ym. (E. gr.) Brass, Copper, Gold, Antimony, Iron, will Swim, if plung'd above 8, 9, 18, 4, & 7 times yeir Thickness, Because they are about 8, 9, 18, 4, & 7 times Specifically Heavier yn Water.

Prop. 6. Lett ABCD be a Vessel of such a figure, as yt its Basis CD be greater yn its upper Superficies AB; I say, That a Fluid contain'd in such
Fig. 21.} a Vessel presses ye Basis CD, as much as a Prism or Cylinder ECDF, whose Basis is CD & height EC, equall to ye Basis & height of ye Vessel ABCD, wd press it. For since (by Cor. of prop. 5) all ye pts of a Fluid comprehended undr ye Same Horizontall plains are Equally press'd, It appears, That ye pts att CN & DM are as much press'd as ye parts att MN. But ye pts att MN are press'd by

Plate 3, Fig 21. by ye Prism or Cylinder ABMN; From whence it appears, yt ye Parts (35
at CN & DM are as much press'd, as ye Prisms or Columns ECNA
FDMB wou'd press ym. Wherefore CD is press'd as much as it wd
be, if ye Fluid ECDF press'd upon it.

Coroll. Hence, since Weight is a Pressure, it Manifestly appears yt ye
Basis CD sustains as much weight, as it wd if press'd by ECDF,
wch tho' it seem a Paradox, ye Experiment confirms:

Plate 4, Fig. 1. Let ABCD be a Cylinder of Brass exactly fitted wth a Moveable Basis,
so contriv'd yt no Water may run out betwn it & ye Side of ye Cy=
linder; let F be a long Brass Tube continu'd to ye top of ye Cylinder,
let a Rope, yt is tied to one end of ye Balance & runs thro' ye Tube,
be fix'd to ye Middle of ye Basis at a; Then pouring Water in at
F, so as to fill ye Cylinder at AD, see what weight in ye Scale K will
be requir'd to move or Raise ye Basis a press'd by a Column of Wat.
ABCD, E.g. Suppose 10lb: After yt, Fill ye Tube wth Water up to ye
Top, wch if it be 3 times longer yn ye Cylinder, you'll find yt yr will
be need of 3 times more Wt to raise ye Basis, yn wn it was press'd
only by ye Column of Water ABCD. whereas it was yn rais'd by
10lb, it will not now be rais'd by less yn 40lb, wch will be ye wt of a
Column of Water, whose Basis is equall to ye Basis BC, & whose
height is Equall to ye Height of ye Tube & Cylinder viz. GCHD.

Horse-hair is reckon'd a Body, yt comes nearest ye Specifick Gravity of Water.

Prop. 7. If in a Fluid, as ABCD, be let down a Body E having a Specific
Fig. 2. Gravity equall to yt of ye Fluid; The Body will be all cover'd in
ye Fluid, & will retain any giv'n position. For if any pt of it,
as E, shd remain above ye Superficies of ye Fluid, yt pt of ye
Fluid, viz. H, yt is under ye Body E wd have a greater pressure,
yn ye pts I & K, wch are only press'd by ye Incumbent Fluid:
For ye imers'd pt of ye Body E presses H of its Self, as much as
ye Fluid in its Room wd do, so yt ye pt yt is out of ye Water ad=
ding to ye pressure, will force ye pt H of ye Fluid out of its place
(by prop. 4) wherefore ye Body E will descend & be all imers'd. &
therefore, as in Fig. 9, wn ye Body E has an Intense Gravity equal
wth yt of ye Fluid; both ye pts under ye Body & yse under ye Fluid
in ye same Horizontal plain are equally press'd: so yt (by prop. 3)
yr arises no Mocon frm such a Pressure. And since ye same
Reason holds good in every Position of ye Body E, it is mani=
fest yt it retains any one yt is giv'n it. Q.E.D.

Prop. 8. If in a Fluid, as ABCD, be imers'd any Body as E specifically
heavier yn ye Fluid; ye Body will descend to ye Bottom, but wth a
Force equall to ye Excess, by wch ye Gravity of ye Body exceeds
ye

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ye Gravity of so much of ye Fluid, as is Equal to it in Bulk.
For if ye Body & ye Fluid were both of ye same Specifick Gravity, ye Body
Plate 4. Fig. 2. } wd not descend (by Prop. 7.) But wn it is heavier yn ye Fluid, ye pts H under ye Body are press'd stronger yn yse under ye Fluid; wherefore by ye Excess of yt pressure, ye pts H will be thrust out of yeir places, & Therefore by ye same Excess ye Body E will descend. Q.E.D.

Cor. 1. A Body imers'd in a Fluid looses as much of its Gravity, as is ye wt of a portion of yt Fluid equall to it in Bulk. For Gravity is a Force wch pushes a Body downwds, Now since a Body descends wth yt Force only, by wch it Exceeds ye Gravity of an equall bulk of ye Fluid, it appears, That it gravitates in water wth yt Force alone.

Exper: Weigh a peice of Lead in ye Air, suppose 12 lb, & afterwards weigh it in water, & find How much it loses of its wt, suppose 17 oz; Observe also, how high ye Lead raises ye water, wn putt into it; Then take out ye Lead & putt in 17 oz of Water, & you will find, yt ye Water added will rise as high in ye Vessell, as ye Lead rais'd it before; & yrefore ye Weight yt a Body loses in ye Water, is just equall to ye wt of as much water, as is equall to ye Body in Bulk; what wt ye Body loses ye Water gets. Ex. gr. Suppose a Vessel of Water weigh 10 lb, if we hang a 12 oz wt in yt Vessel by a String, so yt it may touch neither botto nor sides; The Vessel of Water will weigh 10 lb – 1 oz, wch is just ye wt, yt ye Lead loses.

Cor. 2. Two Bodies, wch are of diff.t Specifick Gravity, as Gold & Silver equiponderous in Air, or rather in Vacuo, being imers'd in a Fluid; That wch is of greatest Specifick Gravity will preponderate. For, since every Body imers'd in Water loses of its Gravity as much as is ye gravity of a portion of ye Fluid equall to it in Bulk; it appears, That yt wch takes up ye least room, i.e. yt wch is Specifically heavier, loses less of its Gravity & so preponderates.

Exp. Take a Crown-peice of Silver, & a peice of Lead of ye same wt, wn they are weigh'd in ye air; afterwds weigh ym in Water, & ye Lead will preponderate.

Cor. 3. Bodies are easier lifted up in Water yn in Air.

Cor. 4. Hence ye wt of any Fluid is easily found, viz. By Imersing a Cubical foot of Lead into it; & its Difference betwn its wt in ye Fluid & its wt in Vacuo, is ye Weight of ye Fluid.

Prop. 9. If in a Fluid, as ABCD, ye Body E, specifically lighter yn
Fig. 3. } ye Fluid, be imers'd; it will not be cover'd, only so much of it as is equall to a portion of ye Fluid, wch is as heavy as ye whole Body. For if ye whole Body shd be imers'd, it appears, yt ye Parts

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parts of ye Fluid under it, are less press'd, yn yse under ye same (37)
Plate 4.) Horizontal plaine are by ye Incumbent Fluid; because ye Gravity
Fig. 5.) of ye Body E is less yn ye Gravity of an equall Bulk of ye Fluid:
wherefore (by prop. 5) ye pts under E will rise, till they come to
such a place, as where ye pressure of ye Fluid AIKD is but equal
to ye pressure of E. i.e. wn ye pressure of ye Body E is equal to
ye pressure of as much of ye Fluid, as wd be put in ye place of
ye Submers'd part.

Cor. 1. Hence since ye Specifick Gravity of Bodies are reciprocally as ye Bulks of æquiponderous ones (by prop. 4.) ye Immers'd pt of ye Body E will be to ye Whole, as ye Specifick Gravity of ye Body to ye Specifick Gravity of ye Fluid.

Cor. 2. Therefore ye Gravity of Bodies putt in a Fluid is 2 fold, one True & absolute, ye Other Relative & apparent: By ye 1st sort of Gravity ye Parts of Fluids & of Solid Bodies gravitate in yeir places, & therefore ye Weights being join'd they compound a Weight of ye Whole. By Relative Gravity, Bodies do not gravitate in yeir places, i.e. they do not preponderate one anothr, but hindring each othrs endeavr to descend, they remain in yeir places, & as if they were not heavy. Those things wch are in ye Air & don't preponderate, ye Comon people don't think heavy, because they are sustain'd by ye Wt of ye Air. Comon Weights are nothing else, but ye Excess of True Weights above ye Wt of ye Air; Fm whence also, those things are call'd Light, wch are less Heavy, & by yeilding to ye preponderate Air mount upwds: They are Comparatively Light, not Truly so, because they do descend in Vacuo. Thus also in Water, Bodies wch descend or ascend by reason of ye greater or less Gravity, are apparently & Comparatively Light or Heavy; & yeir Relative Gravity or Lightness is ye Excess or Defect, by wch yeir True Wts exceed ye Gravity of Watr, or are Exceeded by it.

Cor. 3. The Immers'd pts of Unequall Bodies of ye same Spec: Gravity, in a Fluid heavier yn ymselves, are to Each othr, as yeir Whole-s.

Cor. 4. The Immers'd pts of Equall Bodies having different Spec: Gravitys, are to each other, as yeir Specifick Gravities.

Experiment. Take a peice of Wood, & weigh it, yn sink it in a Vessel as far as it will go wth its own Gravity, & Observe how High it raises ye Water in ye Vessel; Having taken out ye Wood, pour as much Water in ye Vessel as is Equal to ye Weight of ye Wood; & ys will rise up to ye same Surface, as ye Water did before, wn the Wood was in.

prop.

Prop. 10. If ye Same Body E be Imers'd in diff^t Fluids heavier yⁿ it Self; the Imers'd p^t will be reciprocally, as ye Spe: Gravity of ye Fluids. For ye Imers'd p^t of ye Body E in ye Fluid ABCD, fig. 4, is to ye Whole (by 1 Cor. prop. 9) as ye Sp: Gravity of ye Body to ye Sp: Gravity of ye Fluid; & ye Whole is to th' imers'd p^t in ye Fluid aBCD*, as ye Sp: Gravity of ye Fluid, to ye Sp: Gravity of ye Body: Wherefore, (by 23. 5 El. Euclid) ye Imers'd p^t in ABCD will be to ye imers'd part in aBCD, as ye Gravity of ye Fluid aBCD to ye Gravity of ye Fluid ABCD. Q. E. D.

Plate 4, Fig. 4, 5.

*fig 5.

Hence appears a Method of finding out whether any Quantitys of Salt is contain'd in Water; By ye assistance of an Instrument made of Glass (represented Plate 2, Fig. 20.) And since Saltwater is heavier yⁿ Fresh, Find first how deep ye Instrum^t Sinks in Fresh water, and if in trying oth^r water it be less imers'd, 'tis certain yt Salt is contain'd in it, as being heavier; & by how much ye less it is imers'd, by so much ye more ye Salt is in ye Water.

The Excellence of Liquo^rs (e.g.) Wine, is found out by ye same Instrum^t. For, by how much ye Lighter such Liquo^rs are, they are comonly esteem'd so much Bett^r; But yeir Gravity is found out by This mañer.

Prop. 11. To find out w^t Relacon ye Sp: Gravity of a Fluid, & a Body giv'n imers'd in it, have to each other.

In ye first place, Suppose ye Body to be Specifically heavier yⁿ ye Fluid, & let its w^t be found in Vacuo, & yⁿ put it in ye Fluid. as ye w^t of ye Body will be to ye excess (by w^ch ye same Body weighd out of ye Fluid, exceeds its own w^t in ye Fluid) so ye Sp: Gravity of ye Body will be to ye Sp: Gravity of ye Fluid; For ye Sp: Gravity of Bodies equall in Bulk are as yeir w^ts; But ye w^t of a portion of ye Fluid equall to ye Body its self in Bulk is (by Cor. 1, Prop. 8) ye Difference of ye w^ts; Therefore, these being givn, ye Relation betw^n ye Sp: Gravities of ye Body & ye Fluid will be given also. Q. E. D.

But, If ye Body imers'd be Specifically lighter yⁿ ye Fluid, ye Sp: Gravity of ye Fluid will be to ye Sp: Gravity of ye Body, as ye whole Body to the Imers'd part of it, (by Cor. 1. prop. 9.)

Prop. 12. Two Solid Bodies as A & B being giv'n; To find w^t Relacon yeir Sp: Gravities bear to each oth^r. Lett ye Relacon of ye Sp: Gravity of A to ye Sp: Gravity of ye Fluid D be found out, by ye former propⁿ & let ye Relacon of ye Sp: Gravity of D to ye Sp: Gravity of ye Solid B be found also; Fm whence (by 20, 5 El. Euclid) ye Relacon of ye Sp: Gravity of ye Solid A to yt of ye Solid B will be given. Q. E. F.

Plate 2, Fig. 18.

Prop.

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Prop. 13. If upon ye Fluid ABCD, anoth^r Fluid as EADF be pour'd Specifically lighter yn ye former; it will not be imers'd in ye Fluid yet 'twill press its Superficies by its Gravity. For since ye Fluid ABCD is Specifically heavier yn ye Fluid EADF, its force of tending downwds will not be exceeded by ye force of EADF; yet since it is heavy, tis manifest yt it presses ye Superficies AD wth its Gravity.

Plate 4, Fig. 6.

Cor. 1. Hence ye pressure of any Fluid pour'd in (supposing it to be Homogeneous & of ye same Density every where) is always acc. to its Height.

Cor. 2. By how much Specifically heavier ye Fluid is, by so much ye greater is its pressure.

Cor. 3. The Superficies of every Fluid is ~~perfectly~~ pressed by air.

Prop. 14. If ye Superficies of ye Fluid ABCD be press'd by an Incumbent Fluid, but ye part G freed fm ye pressure (wch may be done by ye assistance of a Tube, as lmno;) ye Fluid G will rise above ye Superficies AD, & yt to such an height, as yt ye Superficies mn may be press'd wth as great a force as Am & Dn, i. e. it will rise up to pq. For since ye pt G of ye Fluid is less press'd yn ye rest, it will rise (by prop. 5) & yt, untill mn be press'd wth as great a force as Am & nD under ye same Horizontal plain.

Fig. 7.

Cor. 1. Hence ye Fluid mnpq, wch ascends, has as much Gravity, as ye Quantity mnrs of ye Fluid EFAD wd have, of ye same height as EA & FD.

Cor. 2. Therefore ye specifick Gravities of Fluids are reciprocally to each oth^r, as ye Bulk of ye Ascended Fluid pmnq to ye Bulk nmrs; or wn yse 2 Bodies have equall Bases recip:lly as yeir Hts.

Schol. Since Air presses ye Superficies of all Fluids by its Gravity, (by Cor. 3 prop. 13) if any part shd be free fm ye pressure, it is manifest, by ye foregoing prop. yt ye Fluid will ascend above yt Superficies, wch is not press'd wth air, untill it press ye Superficies under it wth as much Force, as ye Superficies is press'd by ye Incumbent air. And this Proposition is of very great use in Hydrostaticks; for by its assistance, all ye Phænomena's of Nature, wch us'd to be attributed to ye Abhorrence of a Vacuũ, are easily explain'd. Nay many Things are drawn fm it, for ye necessary Uses of Life, as Syringes, pipes, & oth^r such like Machines. But, before we Treat of yse Things, it will not be amiss To speak a few things of ye Toricellian Experimt, & to show ye cause of it fm wt has been above Demonstrated.

Exper: Take a Vessel of Water, & imerse a Tube (open att both ends) into it, yn pour Oil upon ye Water, to ye height of 4 or 5 inches: wch will raise ye Water in ye Tube so high; yt it may press as much on

on ye Surface of ye Water under it, as ye Oil dos on ye rest (40
of ye Surface. vid. prop. 4.5.

Let ye same Experiment be try'd wth Air & Water:
Plate 2, Fig. 19. Take a Drinking-Glass, & turn it so in ye Water, yt it may be fill'd wth Water, ye Air being turn'd out; If ye Glass be raised perpendicular, ye Water will ascend in it above ye Surface of ye Stagnant Water, as at B.

The Air does not only gravitate upon ye Surface of Fluids, but also upon all Solid Bodies; as may be prov'd fm ye Cohesion of 2 flat peices of Glass or Marble exactly polish'd & ground togethr. That ys depends upon ye pressure of ye Air, is plainly evinc'd, by trying ye Experimt in ye Recipient of an Air-pump, for after an Exuction or 2 of Air, ye Marbles drop asunder.

Anothr Argumt for ye pressure of ye Air may be tak'n fm ye Recipients sticking to ye plate, upon wch they're fix'd, so closely, yt after 2 or 3 Exuctions, it requires a Considerable Wt to pull it away.

Prop. 15. To show ye Torricellian Experimt, & explain ye cause of it;
Plate 4, Fig. 8. Lett AD, ye Horizontal Superficies of Quick-Silvr contain'd in ye vessel ADC, be exposd to ye pressure of ye Externall Air, & ye Tube PC, (stopt att P, & open att C) be fill'd wth Q. Silvr; after yt turn it, & imerse its Orifice C under ye Supficies of ye Q. Silvr contain'd in ye Vessel ADC, keeping its Orifice C stop'd wth yor finger, untill it be so imers'd, yt ye Q. Silvr don't run out by turning ye Tube; & yn unstop it, holding it in yt Position. Now Experimt makes Manifest, yt ye Q. Silver in ye Tube CP will not descend below ye height of 27 or 28 inches; & if ye length of ye Tube be not 27 or 28 inches, ye Q. Silvr will not descend att all.

The Reason of ys Experimt appears fm ye foregoing Prop.n For since ye Supficies of ye Q. Silvr AD is press'd by ye Superincumbt Air, but its pt C not press'd; it must needs be, yt ye height of ye Q. Silvr in ye Tube CP be so great, as yt ye Superficies C sustain ye same pressure fm ye Incumbent Q. Silvr, as ye rest of ye Q. Silvr doos fm ye Incumbent Air.

Exper. If we imers'd ye Tube thus fill'd, into Water instead of Mercury, ye Mercury or Q. Silvr in ye Tube will descend, & ye Water will ascend to ye top of ye Tube (by prop. 4.)

N.B. If we Incline ye Tube towds ye Horizon, ye Mercury will rise highr & always keep perpendicular height; for in ye Inclin'd position, it dos not press so much upon ye Subjacent Mercury, as in ye Erect, its Gravity acting partly agt ye Sides of ye Tube.

To prove, yt ys depends upon ye pressure of ye Air; take a Glass Tube 4 or 5 foot long, wch has one end (instead of being Seal'd Hermetically) tyed over wth a peice of Bladder; Fill it up wth Water,

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* This was Experimented att Claromont in France, first
in a low vale, & afterwds on a Hill 3000 foot higher
yn yt vale; in wch latter place ye Qu:silver sunk a:
bove 3 inches lower, yn it had in ye former; Therefore
As 3 inch of ☿ : 3000 foot :: $27\frac{1}{2}$ inch: of ☿ : 27500 f. ~~[illegible]~~ {Rohault part.1.c.12
which being reduc'd ~~multiply'd~~ into miles = $5\frac{1}{4}$ suppos'd Height of ye Air.
Tho' this differs much from ye Reall height of ye
Air (or Atmosphere) as is calculated by many.
Bartholin (c.12) allows it not to be much above
one mile in height. vid. Varenius lib.1.c.19.prop.30.

& imerge it in Stagnant Water; You will observe ye Water not to descend att all; but if wth a pin you make an Hole in ye Bladder, ye water will imediately descend quite out of ye Tube.

Cor. 1. Hence a Cylinder of Q. Silvr of 27 or 28 inches gravitates as much as a Column of air, whose height reaches to ye Top of ye atmosphere, & wse Basis is ye same as yt of ye Column of Q. Silvr.

Exper. We may increase ye Wt of ye air, by sinking ye Barometer into anothr Fluid. viz. put it into a long Cylindricacall Glass, & pour water afterwds on ye surface of ye Stagnant Mercury, & ye Mercury will rise highr in ye Tube, acc. as ye pressure of ye Water encreases; about 14 inches of Water upon ye Stagnant Q. Silvr will raise yt wch was in ye Tube abt 1 inch, yre being abt 14 to 1 betwn ye Gravity of Mercury & yt of Water.

The Tube wth Mercury being put into a long Receiver, ye Mercury will fall down, after ye air is pumped out.

The same Experimt may be try'd wth Water in ye Tube, but ye Water will not subside so fast as ye Mercury did. And if in ye Tube yre be left a small Air-Bubble, ys Bubble will expand it self, & fill ye whole cavity of ye Tube; ev'n so much, as to depress ye Surface of ye Water in ye Tube, below ye Surface of ye Stagnt Wa[ter].

* Cor. 2. If Air were of ye same Density, att all distances fm ye [superfic]ies Earth, its height cd be easily found out; For as ye difference of ye height of ye Q. Silvr on ye top of a Mountain is to ye height of ye Q. Silvr att ye bottom of ye Mountain :: so ye height of ye mountain is to ye Height of ye Air.

It is manifest yt a Cylinder of Water of 32 foot gravitates as much upon a Fluid under it, as ye Air does upon ye other pts of it; Therefore, Watr can be sustain'd att such a height by ye Gravity of ye air.

Schol. I have said yt Q. Silvr is sustain'd at 27 or 28 inches, for ye Gravity of ye Air is various & mutable; sometimes Q. Silvr will remain 27 inches, sometimes 28, & now & yn it will ~~ascend to~~ ascend to 29 or 30 Inches: Fm hence it must needs be yt ye Gravity of ye Air is chang'd proportionably to its Height.

By how much ye heavier ye Air is, so much ye Easier can it sustain Vapors rais'd by ye Heat of ye Sun; for Vapors are nothing but watry particles rarified by ye heat of ye Sun, & yrefore ye same particle of water taking up a greater Space, becomes specifically lighter yn air; fm wnce of necessity, yt particle must ascend, untill it come to air, whose Sp: Gravity is equall to its own where it must Rest: But ye Gravity of ye Air decreasing, it must needs

ℭ Suppose a Column of air reaching fr ye Top of ye Atmosphere, whose Base is one q. inch, to weigh (acc. to computacon) abt 10 ℔; and a moderate mans Surface of his Body being 15 q. foot, of wch every inch sustains 10 ℔ weight of air: The whole Man sustains continually no less yn 21600 ℔ of Air.

$$\overset{q.f.}{15} \times \overset{q.in.}{144} = \overset{q.in.}{2160} \times \overset{℔}{10} = \overset{℔}{21600}.$$

*

X would be press'd equally by ye Atmosphere, (so yt ye Reaction of ye air in one Tube wd be equal to ye Impulsion in ye other;) & if DE

needs be, yt ye Vapours will descend, wch by ye Resistance of ye air in yeir Motion are form'd into Drops of water; from whence it cannot but Rain, wn ye Gravity of ye air is lessen'd. But wn its Gravity is encreas'd, ye Force also is encreas'd, by wch it is able to Sustain ye Vapours, & yt remaining, ye air is Clear. Hence it is yt such a Tube fill'd wth Q. Silver & immers'd within ye Superficies of Standing Q. Silver is us'd to Show ye Gravity of air, & Fair weather, wch follows from it.

Prop. 16. The Elastick force of air inclos'd in a Vessel of ye same Tenor wth ye Ambient air, performs as much as ye whole Burthen of ye open Incumbent air.

Let yre be a Tube or a Vessel having an open Orifice, by wch yre may be a Comunication betwn ye Internall & Externall air; If yn ye adjacent pts of ye Externall air be less press'd yn yse wch are within ye Vessel, These will dilate ymselves (by Prop. 5) till they come to an equall Force: But if ye Externall adjacent pts are more press'd yn yose within, Those yt are within will be compress'd, untill yeir Elastick Force is Equivalent to ye Force pressing from without. Q.E.D.

This appears from Mr Boyle's Experiments.

Cor. 1. From ys follows ye Reason why we don't feel ye weight of air.

Cor. 2. From Hence also we know, why we do not feel ye wt of Water

Cor. 3. Lett CD be a Pipe or curv'd Tube open att both Ends, one of wch, as C, is immers'd in Water or any other Fluid, ye other, as E, being longer yn C from ye Curve, hanging without ye Fluid; If yn by sucking, ye Liquor comes to E untill it runs out, It will continue running, altho' you dont suck it, till ye Liquor in ye Vessel be either all drawn out, or wants a due height: Yet upon ys condition, yt ye Orifice E be lower yn ye Superficies AB of yt Liquor in ye Vessel; For ye Air being suck'd out of ye Tube into ye Thorax, ye Fluid under it is forc'd into ye Pipe by ye pressure of the External Incumbent air (by ye preced. Prop.) Therefore ye Fluid will rise to ye Top D, untill yre is an Aequilibrium wth ye pressure of ye Externall air (suppose ye height IG i.e. in Q. Silver abt 29 inches, in Water abt 33 foot, & so in other Liquors proportionably to yeir Gravity) & will run out, as soon as it finds a Passage, because ye Water gravitates in ye Longer Tube; & ye Reason, why DE ought to be longer yn DC is, because, If twere otherwise, both C & E shd be Shorter, yn ye Fluid wd be carried Contrary. But if D be higher yn I, ye Fluid will be forc'd upwds, as far as I, but not farther.

Plate 4, Fig. 13.

Exper. Take a Tube of ys Shape,* open att A, B & C, & having immers'd ye Ends B & C into 2 diff! Small vessels full of water, put ye whole into

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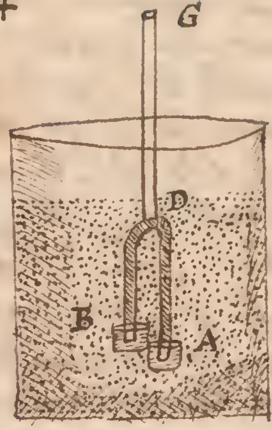

into a‡ Cylindriacal Jarr or Glass; yⁿ pouring in Oil of Turpen=tine up to D above yᵉ bent part of yᵉ Tube; And yᵉ Water will run out of yᵉ Vessel A into yᵉ Vessel B: Wᶜʰ shows, yᵗ a Competent pressure of a Lighter Fluid will make Water come over by a Syphon, ev'n tho' yᵉ Air comes in att G. And this shows plainly yᵗ yᵉ Fuga Vacui has nothing to do in ys Experimᵗ or othᵉʳˢ of yᵉ like Nature.

Take a Recurve Tube wᵗʰ one End longer yⁿ yᵉ othᵉ, & pour water in, till it rises in both to yᵉ height A; afterwᵈˢ put yᵒʳ finger on yᵉ Orifice A, & pour in Water att B, till it rises to yᵉ Top, yⁿ put yᵒʳ Finger upon B & leave yᵉ Orifice open, & yᵉ Water will not run out at A: But if you take off yᵒʳ Finger, yᵉ Liquoʳ will run out att A, till it has Subsided in yᵉ Leg B down to yᵉ levell of yᵉ Orifice A.

Plate 6, Fig. 4.

Mercury will rise yᵉ same way, but not to yᵉ same height, since it will rise no higher yⁿ it does in yᵉ Comon Baroscope, i.e. 14 times less yⁿ yᵉ Water, it being 14 times heavier; for Mercury rises but to 30 inches, Water to about 33 Foot.

If yᵉ Romans had known yᵉ Pressure of Air cᵈ raise water to such an height, they need not have been att yᵉ trouble of cutting thro' Mountains, to make yeir Aqueducts Levell.

Schol. The Ancient Philosophᵉʳˢ ridiculously Explain'd ys by yᵉ Abhorrence of a Vacuum; in yᵉ place of wᶜʰ now deservedly succeeds, yᵉ Æquilibrium of yᵉ Air: Galilæus first Thought of it, & Torricellius mantain'd & prov'd it.

Cor. 4 The same Thing holds good in yᵉ Pump; wᶜʰ is made of a long peice of Timber cut Cylindriacally wᵗʰin & immers'd in yᵉ Well, yᵉ upper part of wᶜʰ standing above yᵉ Superficies of yᵉ Watᵉʳ (wᶜʰ Water is not to be Suppos'd Free fm yᵉ pressures of yᵉ Air, but exposed to it, othᵉʳwise it wᵈ not be thrust upward;) & in some part of yᵉ hollow of yᵉ Pump yʳᵉ's fix'd a peice of wood across, in yᵉ middle of wᶜʰ there is yᵉ hole D, thro' wᶜʰ yᵉ Water ascends; & over ys hole is a Valve or Clack, as E, so plac'd across, as to open or shutt according to its being press'd fm above or below; also a Bucket as FG lett down fm above by yᵉ Rod or Handle (so fitted to yᵉ sides of yᵉ hollow Cylinder, as yᵗ yᵉ Air can have no passage betwⁿ) wᶜʰ also hath an hole in yᵉ middle of its Bottom, & a Valve G fitted to it, as hath DE.

Plate 4, Fig. 12.

Things being thus order'd, while by moving yᵉ Handle yᵉ Bucket is drawn up (yᵉ Air being upon it, & by yᵗ means yʳᵉ will be a less pressure of Air upon yᵉ Water below yᵉ Bucket) yᵉ Water in yᵉ Well being press'd by yᵉ Ambient Air will be forc'd up into yᵉ hollow of yᵉ Pump, thro' yᵉ Hole D (opening yᵉ Valve E) as far as yᵉ Bottom of yᵉ Bucket (provided it be not higher yⁿ I yᵉ top of yᵉ Æquilibrium) being free fm any pressure fm above, & thrust up fm below. But

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But on yͤ Contrary, by turning yͤ Handle yͤ other way, yͤ Buck= 44
ett is press'd down & presses yͤ Water imediately under it, wch ascends
Plate 4. Fig. 12. thro' G; by ys depression E is shut & G open'd, thro' wch yͤ Water having gott above yͤ Buckett is drawn up wth yͤ Buckett, wn it is drawn back (yͤ Valve G being shut) & finding passage flows out at H: then Water rising again thro' D, succeeds, as before, in yͤ place of yͤ Buckett, yt is drawn up, & so Continually.

Prop. 17. Concerning yͤ Elasticity of yͤ Air, and some Effects depending upon it.

The Elastick Force of yͤ Air is yt, by wch a Compress'd quantity endeavours to expand it self into a greater Space. And since yͤ Air att yͤ Superficies of yͤ Earth is much press'd by a great Weight of yͤ Incumbent Air; It must needs be, yt it will endeavr to recede fm yt pressure every way, & break into wtsoever Space its Empty & Free fm Pressure, where by its Elastick Force it will expand it Self equally, & uniformly press all yͤ given pts of yt Space.

Exper. Lett a Bubble fill'd wth Air of yͤ same Tenour wth yͤ outwd air, be hermetically seal'd; yn Heat it att yͤ Flame of a Lamp, & yͤ Air being expanded by Heat, will break yͤ Bubble.

If any Elastick Body be compress'd by a Superincumbent wt, it will endeavour to Expand it self equally on all sides by its Elastick Force, & so equally push yͤ Wt upwds, & yͤ Table, by wch it is Sustaind, downwds.

But if instead of yͤ Wt, be putt any thing yt may resist yͤ Restitutive force of yͤ Body, yn yͤ Elastick Body will endeavr to expand it self after yͤ same manner wch it did att first, & so will push
Plate 6. Fig. 16. yͤ Table, by wch it is sustaind wth yͤ same Force also, as att first, as also yͤ Thing wch resists it, tho' in vain. See Fig. a Worm-Spring.

By how much yͤ more an Elastick Body is expanded, yt resists any Compression, by so much yͤ less will its Restitutive Force be, & so on yͤ Contrary; & therefore yt Force is always Equivalent to yͤ Powr yt compresses it. Therefore yͤ Density of yͤ Air is always as yͤ Force pressing it; so yt since yͤ Air wthin is restrain'd in its Density, by yͤ Wt of yͤ Superincumbent air, if a double Wt be apply'd, it will become twice as Thick, & be compress'd into half yͤ Space; if it be compress'd wth thrice yͤ Force, it will be forc'd into 3 times less Space: So likewise, if half yͤ Incumbt air shd be tak'n away, yͤ compress'd air will expand it self into twice yͤ Space it had, whilst compress'd, &c.

Hence, since Air contain'd wthin yͤ Walls of an House, is of yͤ same Density wth yͤ same Externall air, wth wch it comunicates, It will endeavr to Relax it self equally wth yͤ Externall air, & will press yͤ Superficies of Fluids wth yͤ same Force, as if yͤ Fluids were expos'd

[illegible]

expos'd to ye whole Incumbent air: and yrefore air wthin (45
an House will keep Q. Silvr att ye same height in ye Torricellian
Tube, as if it was expos'd to ye whole wt of ye Incumbt air; Nay
some pt of ye air of ye same Density wth ye Externall air, Shutt
up in a Vessell wth Stagnant Q. Silvr, will by its Elastick Force,
keep ye Q. Silvr in ye Tube att ye same height as before.

Exper. Take a Drinking-Glass & imerge in Water, so yt ye air may not
gett out of it, if you sink it all under Water, ye Cavity will not
(Plate 2. Fig. 19.) be fill'd, ye air wthin hindring ye ascent of ye Water; wch
may be shewn, by putting paper into ye Bottom of ye Glass, wch
will not be wett; But if you sett ye Paper on Fire, ye air by Heat
being somewt expell'd, ye Water will rise a good way in ye Glass.

Upon this principle Diving Bells are made, by wch Divers descend
into ye Bottom of ye Sea, & breath freely under Water; yet ye
farther ye Bell is sunk ye more ye air will be compressed; wn
tis abt 33 foot under Water, ye air will be compress'd to half
ye Space, wch it was before; This sometimes breaks ye Blood-
Vessels & makes ym Bleed att Mouth, Nose & Eyes.

Take a Mortar, & bind a peice of Leathr on ye Mouth of it, yn take
a Cupping-Glass, & having rarified ye air by Heat, imediately
fix it to ye Leathr to wch it will adhere very strongly; and ye
Leathr will swell wthin ye Glass, because ye air in ye Mortar
has more Force yn yt wch is rarified wthin ye Glass, & yrefore
presses ye Leathr outwds; The Glass sticks to ye Leathr, because
ye Externall air presses it down. Upon ys Principle Cupping
is explain'd, The Internall air in ye Blood rarifies, wn ye pres-
sure of ye Externall is tak'n away, & distends ye Skin, & makes
it swell in ye Glass. This is a proof, yt yre's a great deal of air in
ye Blood.

Prop. 18. To Show, yt ye ascent of Fluids in Tubes after
Suction, arises fm ye pressure of ye air.

(Plate 4. Fig. 14.) Wn a Man by ye Muscles of his Breast enlarges ye Cavity of
his Thorax, yn ye Externall air finding Room to expand it selfe,
rushes in att his Mouth into his Lungs; So yt if one Orifice of a
Tube be in his Mouth, & ye othr imers'd in Water, yn yt part
of ye Supeficies of ye Water wch is under ye Tube, is free fm
pressure; & since ye othr pts of ye Supeficies of ye Water are press-
ed by ye supincumbt wt of ye Externall air, it must needs be
(by prop. 5) yt ye Water ascend up into ye Tube, viz. yt ye pt
under ye Tube may be equally press'd wth ye Incumbt water, as
much as ye rest of ye Supeficies of Water is press'd by ye Incumbt
air,

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× Not as it was, wn Mr Boyle made use of it (wch Description is to be found in Harris's Lexicon Technicū under ye Word Air pump;) But as it has been Since alter'd & Improv'd.

air; so yt ye pressure of ye Externall air upon ye Supficies of ye rest of ye Water, is ye Cause yt ye Watr ascends up ye Tube. 46

Exper: Take a Glass wth a narrow neck, but wthout a Bottom, put a Tube in its neck & cement ym; then tye a Lambs Bladder to ye end of ye Tube wthin ye Glass, & a large Ox-Bladder over ye open end of ye Glass, so yt ye Bladder may be forc'd inwds & drawn outwds: Wn ye Bladder of ye Ox is forc'd inwds, you will Observe all ye Air, wthin ye Lambs-Bladder wherein ye Tube is inserted to be expell'd; If you draw ye Ox Bladder outwds, ye Air will rush into ye Lambs Bladder.

Plate 6. Fig. 15.

After ys manner Respiration is perform'd. The air in ye Cavity of ye Thorax acts on ye Lungs, just as ye air in ye Ox-Bladder does on yt of ye Lambs. If ye Openend of ye Tube be immers'd in Water, & ye Ox-Bladder drawn back, ye Water will ascend in ye Tube, & fill ye Lambs-Bladder. Vide Prop. 19.

Prop. 19. The Ascent of Water in a Syringe arises fm ye pressure of ye Externall air. viz. wn ye Tube of ye Syringe is immers'd in a Vessel of Water att q, ye Piston being brt to RS is left void of Air, so yt ye Gravity of ye Externall air pressing upon ye Supficies O & P, will make ye Water ascend in ye Tube as high as RS, viz. yt ye part of ye Supficies of ye Stagnant water att q may be press'd by ye Incumbt water in ye Syringe by ye same Force, as ye Supficies OP is by ye Incumbent Air.

Fig. 11.

A Description of ye Air Pump.+

Plate 5, Fig. 1st. Represents ye Pump wth all its Apparatus.

DD is ye Handle, wch turning wth ye Nutt BB raises or depresses a Rack AA, fasten'd to ye Embolus, wch rises & falls in ye Cylinder, i.e. in ye Body of ye Pump, & can't be seen in ys Figure, But is represented*, as it is, wn taken out of ye Frame.

*Fig. 5.

C is a plate of Iron, screw'd down wth 4 Screws upon ye uppr pt of ye Pump, wth a notch fil'd in it, for ye Back-part of ye Rack to slide up & down in. as also represented +

+Fig. 2.

FI is ye Receiver, open att Both Ends. GG a Smooth Brass plate laid on ye Receivr, wth a Wet Leather, to keep out ye Externall Air.

H is a Brass Collar wth Cork & Oil'd Leathers, to let ye Wire KI be drawn up & down wthout admitting ye Air.

MNM is ye Brass plate of ye Air-pump, on wch ye Receivr stands, wth a Wet Leather between ye Plate & Receiver.

LL

y

LL is a Board an Inch & half thick, supported by ye Iron (47
Plate 5. prop P, wch is rais'd att Right-angles wth ye Side of ye Pump ab, to support ye Plate & Receiver, wn ye Pump is made use of; otherwise it hangs down by means of ye hinges a & b.

VT is a Brass Pipe, wch lies in a Groove made in ye Board, having a Comunication wth ye Cylinder towds T, & wth ye Plate, Receiver, & Mercuriall Gage at N.

R is a Lock, to lett ye Air into ye Exhausted Receivr att pleasure wch will run in fm V to N, & so up to ye little upright pipe into ye Receivr.

O is a Glass Vessel wth ☿ in it, to receive ye End of ye Glass Tube or Gage NO, wch has a Graduated peice of Box, to Shew how high ye ☿ rises, & conseq. how much ye Receivr is exhausted.

S is a Board, wch Supports ye Vessel O.

Kk are 2 Iron Skrews, to Skrew ye Pump to ye floor of a Room, wn ye Experimt requires ye Engine to be very Steddy. also*

*Fig. 8. E is a Lock to lett out ye Water, wch must be kept att AB, above ye Cylinder, wn You use ye Pump.

~ Fig. 3d is a Brass Cylinder close att ye bottom, for ye Piston (fig 4.) to move up & down in. This Cylinder is Skrew'd down to ye Stock of ye Pump, being lett down into ye Box under AB; & yre is Cement made of Pitch & Brick-dust pour'd hott into ye Box att ye outside of ye Cylinder, wch growing Hard, wn Cold, keeps it fix'd.

T is a Hole to Receive ye Skrew of ye Pipe XY of fig. 7.

~ Fig. 4th repts ye Rack A & Embolus BB, wch make up ye Piston of ye Pump.

gg is a Brass plate fix'd to ye Rack abt 1/4 of an Inch less in Diameter, yn ye Innr Diameter of ye Cylinder.

ee, ff repsent 3 or 4 peices of Sheep's Leathr oil'd & very soft, abt 1/2 an Inch more in Diameter, yn ye Bore of ye Cylinder, wch being put on immediately below ye Plate gg will fold round ye sd plate up towds A, wn ye Piston is lett down into ye Cylindr.

cc is a Stiff peice of Shoe-Sole-leathr, whose Diameter is so nearly equall to yt of ye Cylinders Bore, yt it must but just Slip down into ye Cylinder without Friction.

BB is a Brass plate skrew'd on att ye Bottom of ye Rack, to keep ye whole Embolus togethr.

Wn ye Piston is lett down into ye Cylindr below ye Hole T, the Air betwn T & V easily passes upwds by ye Side of ye Embolus, folding ye soft leathr up round ye Plate gg; But wn you draw it fm ye Bottom, no Air can gett down below ye Embolus, because ye Space betwn ye Sides of ye Cylinder & ye Plate cd is not Large enough to lett ye Air fold downwds; so yt ye greater ye pressure of ye Air &c

z

X N.B. Tho' ye Externall air can come into ye Pipe LT, it cannot gett into ye Exhausted Receiv^r, because ye Valve is shutt closer towards NM, ye more ye air presses upon it, being made only to open tow^ds L.

& of ye Water (wch lies on ye Embolus) is, ye more ye Soft (48
Leather is press'd to ye Sides of ye Cylinder; & yrefore ye passage
Plate 5.} downwds round ye Embolus must be close stopp'd & keep out
ye Air, ev'n tho' ye Bore of ye Cylinder shd not be truly Round.
Fig. 7thly is a more Exact Representacon of ye Pipe VT of Fig. 1.
YX is that pt, wch is to Skrew into ye Cylinder, having a Square place att Y to receive ye Key of fig. 5, wch serves to turn all ye Skrews wth it End s or its End r.
Zcab is yt part of ye Pipe, wch lies under ye Plate yt is Skrew'd on at Z. c is to Skrew on to ye pt Y, att T in fig. 1.
a is a Skrew to receive ye Gage, att ye place mark'd N in fig. 1. It must have a Valve of wet Bladder att ye End of ye Skrew b, to wch ye Cock R is to be Skrew'd by applying ye Key Q to ye Square place near b.
Fig. 6th is ye Brass plate 1/4 of an Inch thick, wch is truly flat, having a Brass Brim round it, to keep ye Water frm Spilling, wn it is made use of in any Experiment.
P is a Hole in ye Plate, wth a Skrew to receive ye little pipe, yt stands upright under ye Receiver.
N is ye Plate wth ye Bottom upwds, showing ye Skrew yt fits ye hole Z of ye pipe of fig. 7, att ye place mark'd N in fig. 1.
The Receiver is Exhausted in ye following manner: Wn by means of ye Handle or Winch DD, ye Embolus is rais'd above ye Levell of ye pipe VT in fig. 1 (i.e. above ye hole T of ye Cylinder, fig. 3) yre is a Vacuu in ye Cylinder under ye Embolus, & in ye Pipe TL so yt ye valve att T being no Longer press'd, ye air in ye Receiver easily lifts it up, & by its Elasticity expands its Self, so as to fill ye void Cylinder. Then depressing ye Embolus, ye air comes up out of ye Cylinder, betwixt its Sides & ye Embolus, & so comes Bubbling out thro' ye Water att AB: and raising ye Piston a second time, ye air in ye Receiver (tho' pretty much Rarified already) lifts up ye Valve att T & runs into ye Cylinder wth Ease, to
✗ fill ye Void Space under ye Embolus, & yn is Express'd out as before.
~ And so on, till ye Receiver is quite Exhausted, wch may be known by ye Rising of Mercury in ye Gage; For wn it is gott up to ye same height as yt, att wch it Stands in ye Barometer, ye Receiver is Exhausted; Because ye pressure of ye Air being wholly taken off frm yt pt of ye Surface of ☿ wch is directly under ye Tube, ye Externall air will press upon ye other pt of ye Surface of ye stagnant ☿, & so raise ye ☿ in ye Tube, till it makes an Æquilibrium wth ye weight of ye atmosphere.

Exper-

α

1. Lay yor Hand on ye Mouth of a Small Receiver, & by ye Pump draw out ye Air, & yor hand will swell wth in ye Receiver; after a few Suctions, ye Air will press yor Hand so, yt you cannot raise it.
2. Tie a Bladder to ye Mouth of ye Receivr & Extract ye Air; then ye externall air will depress ye Bladder so much, yt a Mans Strength will not be able to Sustain it.
3. Invert a Receivr & tie a Weight to ye neck of a Bladder over ye mouth of ye Receiver & hanging on ye outside of it; having drawn ye Air out of ye Receivr, ye outwd Air will press so on ye Bladder, as to thrust it up into ye Receiver, & raise ye Wt.
4. Take a peice of Glass & putt it on ye Mouth of ye Receiver; having drawn out ye Air, ye Wt of ye Incumbt Air pressing on ye Glass, will break it. — By this Experimt we prove yt ye Air presses every way, for in wtsoever position ye Glass be, it will still be broken by ye Incumbt Air.
5. In ye Torricellian Experimt If ye Tube wth ye Mercury be put into a long Receivr, ye ☿ will fall down att ye Exuction of ye Air.
6. The same Experimt may be try'd wth Water in ye Tube; but it is to be observ'd, yt ye Water will not Subside so fast as ☿.
7. If in ye Tube yre be left a Small Air Bubble, ye Bubble will expand it self & fill ye Whole Capacity of ye Tube; ev'n so much as to depress ye Surface of ye Water in ye Tube, under ye Surface of ye Stagnt Water.
8. A Fluid Bladder, after ye pressure of ye Externall air is tak'n off, dilates it self as far as it can.
9. The Expansion of ye Air in a Bladder will raise a Wt, after ye Externall air is taken away.
10. A Bladder, in wch Wts are putt to sink it under Water, will rise wth its Wt after ye Extraction of ye Externall air.
11. A peice of Cork, to wch is ty'd just so much Wt as to make it Sink all under water, except ye upper Surface of it, after ye Air is extracted, will rise higher; but wn you lett ye Air in again, will immediately Sink towds ye Bottom.
12. Fishes in ye Watr in ye Recipient, will rise to ye top of ye Water, wn ye Air is drawn out.
13. A Glass Bubble, in wch is left just so much water as to make it Sink, after ye Extraction of ye Externall Air, will rise.
14. If you draw out ye Air of a Square Glass-Bottle, ye Weight of ye Incumbent Air will break it to peices.
15. If you putt such a Bottle, so closely Stopt, yt none of ye Air can gett out

6

* A Description of ye Condensing Engine & its Apparatus, Plate 6.

Fig. 6th is a Syringe or Syphon for Injecting Air into ye Vessel aaaa of fig. 10.

Fig. 9th A Mercuriall Gage made wth a Glass Tube cc fix'd into a peice of Wood, to know ye rising of ye ☿ in ye Vessel aaaa.

Fig. 7. bbbb represent ye Brass Hemispheres; g a Cock to keep ye injected Air fm coming out; ee a hollow peice of Brass, thro' wch ye Air is injected; dd a Brass plate to shutt up ye bottm of ye Vessel aaaa; a one of ye brass Rings, to hang ye wts on to draw ye Hemispheres asunder.

Fig. 10. k ye other brass Ring for ye abovementiond purpose; aaaa is a Glass Vessel arm'd wth brass hooks at c, ye better to keep in ye Air condens'd upon ye Hemispheres bbbb, wthin ye said Glass; f a peice of Brass screw'd to ye upper Hemisphere, to sustain it by help of ye peices ee g hanging upon ye Hook k, whilst ye wts in ye Scale draw ye lower Hemisphere fm it, without letting out ye Condensed Air; hh a Board wth 2 screw'd pillars to fix ye upper & lower brass plates to ye Brass Ves-

Fig. 8. sel; dd ye upper brass plate represented in fig. 8. wth ye Collar of Leathers ff, yt ye peice ec (fig. 7) may slip up & down without letting out ye Air.

If ye air

out of it into ye Receiver; after you have drawn out ye Ex= (50
ternall air, yt wch is wth in ye Bottle, will so dilate it self as to break ye Bottle.
16. If you put 2 Brass Hemispheres together, shutting ym one wthin ye other, & only putting a peice of wet Leathr betwn ym; If, after ys, you pump out all ye air, & by ye help of a valve att ye Bottom of one of ye Hemispheres, ye air can't return into ym, They'll stick so closely by reason of ye Externall air, yt it will require a very great wt to pull ym asunder.
17. If you putt any Animal into ye Receivr, & pump out ye air, ye Animal will imediately dye.
18. If you take a Glass Bottle half full of Water, having a Glass Tube Cemented in ye Neck of't, one end of wch is below ye Surface of ye Water, & ye Othr being above ye Top of ye Bottle has a Brass Top wth small holes in it; If you putt ys into ye Receivr & Pump out ye air, ye air in ye Bottle will so dilate its self, as to press on ye Surface of ye Water & raise it up in Spouts thro' ye Holes of ye Tube like a Fountain.
19. If you putt a Bell so rais'd on a Wooden frame yt it may have powr to move, into a Receivr & pump ye air out; yn if you shake ye Pump so as to move ye Bell, you'll scarcely hear ye Sound of't. This is a proof, yt Sounds depend on ye air.
20. If you putt a Glass of Warm Water into ye Receivr & pump out ye air, ye Water will perfectly seem to Boil: ye Reason is ys, viz. The Elastick force of ye air, wch is in ye Water, being encreas'd by Heat & not being press'd by any Externall air, it endeavours to Dilate it self, & by yt means makes ye Water Bubble up: This is ye Way, by wch ye air may be almost all extracted fm ye Water.

✱ Prop. How to Condense ye air, so yt you may putt wt Quantity you please into a Vessell.

If you have a Brass Vessel, suppose half full of Water, wth an Hole on ye Top of it, into wch you may Screw a little Brass pipe att A, wth a Cock att B, by wch you may lett in ye air; if on ys you Screw a Syringe, wch has att ye Bottom a Valve, by wch ye air forc'd into ye Pipe, may be kept fm returning again, & likewise a Curve Tube skrew'd to it att C, or only a small hole & a Valve att ye same place; If yn you draw up ye Syringe, ye air will come in thro' ye Tube D into ye Syringe att C, & ye Valve will yn hinder it from returning; If yn you open ye Cock at B, & thrust down ye Sucker, ye

Plate 4.
Fig. 10.

Air

7 If ye Air be Exhausted out of ye Hemispheres (joyn'd only by a Wett Leath^r) 'twill require above 130 lb to draw ym asunder; if ye Density of ye Air in ye Vessel a a a a be doubled by ye quantity of Injected Air, on ye outside of ye Hemispheres tho' ye Air is not drawn out fm betw^n ym, it will require as much W^t to draw ym asunder, as before; & double yt W^t, if yre is a Vacuu betw^n ye Hemispheres, or if ye Air be 3 times as Dense as att first; & if ye Air being 3 times as Dense as att first, yre be a Vacuu betw^n the Hemispheres, it will require 3 times ye W^t, viz. 390, to pull ym asunder.

Plate 6, Fig. 10.

air will likewise descend into ye Vessel, & by ye Valve att (5) ye Bottom of ye Syringe be hindred fm returning. By repeating ys Often, you may put wt Quantity of air you please into a Vessel. If yn you take off ye Syringe, & skrew on in ye place of it a Pipe wth holes; wn you open ye Cock, ye Air pressing forward hard on ye Water, will force it up to a great height & will Spout it out in Figures, according to ye Holes of ye Pipe.

Of Barometers, Thermometers, & Hydrometers.

It is Evident fm what has been already prov'd, yt ye Mercury wth in ye Tube gravitates as much on ye Surface of ye Stagnant ☿, as ye Air does on ye rest of its Surface; & yt a Column of Air reaching to ye Top of ye Atmosphere is of ye same wt, wth a Column of ☿ of ye same Basis, & of an height equall to ye ☿ in ye Tube. Now if ye Air shd grow heavier, & press more on ye Surface of ye Stagnt ☿, then ye ☿ in ye Tube must rise higher, yt it may be equall in wt to a Column of Air of ye same Basis reaching to ye top of ye Atmosphere.

Hence it follows, yt ye Height of ye ☿ in ye Tube, may be fitly applied to measure ye Gravity of ye Air: & on yt account, an Instrument fitted to ye purpose is call'd a Barometer.

Sometimes ☿ rises 30 inches, sometimes it stands att 29, sometimes att 28, sometimes it will sink to 27, but seldom under, & of Consequence ye Gravity of ye Air must alter pportionably.

Since Gravity is always proportionable to what ye Matter weighs, 'tis Impossible yt ye Air shd change its Gravity, wthout changing its Quantity of Matter; & therefore some have thought ys Difference of ye Air's Gravity to proceed fm its being more or less overcharg'd wth Vapours: If ys were ye Case, yre must be as many Vapors in ye Air att a Time, as are Equall to 3 inches of ☿, for so much we find ☿ rises or falls.

Now Mercury is abt 14 times heavier yn Water, & conseq. yre must be in ye Air att once as many Vapors as will equall in Length a Column of Water of 42 inches high, & whose Basis is Equall to ye Surface of ye Earth; wch is more yn falls down in a whole year, Rain: For ye Rain during a whole year does not fill a Vessel above 14 or 15 inches high, As is observ'd in ye History of ye R. Socty att Paris.—The

The Reason yn, why ye Air is heavier att one Time yn anothr; (52
arises fm ye being more Air in yt pt of ye Earth's Surface, whr
ye Air grows heavier. And ys proceeds fm Winds; (v.g.) If ye
Wind (wch is nothing but a Stream of Air) shd blow over any
place, & ye Air thus mov'd shd be kept in yt place by Mountains or Hills; or if 2 contrary Winds shd blow in ye same
place, ye Air will be heap'd up in ye Middle, & conseq. yr being
more Air, its Gravity will be encreas'd: But if ye Wind
shd blow over a Country, ye Air wch is over yt place, will be
less in Quantity, & conseq. lighter. Hence 'tis plain, yt Winds
are ye only Cause of ye Air's Gravity.

When ye Air is heavy, ye Sun acting on ye Surface of ye Water, raises
ye Vapours fm it; yse being rais'd are Specifically Lighter
yn ~~ye~~ Air, & conseq. they must rise higher till they come to an Air
of ye same Specifick Gravity wth ymselves, where they will Rest:
and a vast Collection of yse Vapors form Clouds. So long as
ye Air Continues heavy, ye Vapors will be sustain'd, & ye Weathr
will be Fair: But if ye Air turns lighter, ye Vapors wch were
in Æquilibrio wth it before, will now preponderate & conseq.
descend; in yeir Descent being continually check'd by ye Resistance of ye Air, wth wch they meet, they will be Condens'd;
This Condensation will still grow more & more, till att last they
are form'd into drops of Rain.

Hence it follows, yt wn ye Mercury in ye Tube is high, yn ye Weathr will
be Fair; & wn it falls low, ye Vapours yn not being sufficiently sustain'd by ye Air, must also Fall, & ye Weathr will be Rainy
& ye Rain more or less, acc. as ye ☿ rises or falls in ye Tube.

Upon ys Principle Comon Weathr Glasses are made; but to make ye Change
of ye Air's Gravity more Visible, Sevl Instruments have been contriv'd.

1. The Wheel-Barometer, Which Consists of a Recurve Tube ABCGE

Plate 2, Fig. 21. fill'd wth ☿; ye Gravity of ye Air pressing on ye Surface E, yre
swims a Leaden Ball tied to a String, att ye othr End of wch yre
is also tied a Wt; & ye String runs on a Pulley att C, to wch yre is
an Hand or Index applied, wch moves along wth ye Pulley; & a
large peice of Brass BFGE divided into any number of equall pts
mark'd 1, 2, 3, &c. Wn ☿ falls att B, it must rise att E, & conseq.
raise ye Ball wth it, whereupon ye Wt att D will descend lower, &
draw ye String wth it, & by ys motion, ye Pulley being turn'd, ye Hand
will shew ye least Variation of ye Air.

This

This was Invented by Dr Hook; but ys Instrumt has one Inconvenience, wch makes it almost useless, for in Damp Weathr, ye String to wch ye Wts are tied is contracted, & in dry, will grow longer. By this Motion it will move ye Hand, wn in ye mean time ye ☿ has neithr ris'n, nor fall'n. A Watch-String will do bettr than an Iron Ball. 53

2. Hugens contriv'd anothr Instrumt, after ys Mannr.

Plate 6, Fig. 18. ABCDEF is a Recurve Tube so made, yt ye 2 parts of it AB & DE have a much greater Basis yn ye Rest; The Tube being fill'd wth ☿, ye Gravity of ye Air pressing on ye Surface att G will sustain ye ☿ to ye height AB, & ye pts AB & DE being of an Equall height, if ye ☿ fall an Inch att AB, it will rise as much att DE. Thro' ye Orifice M on ye Surface DE is pour'd Oil of Tartar pr Deliquiu, or Spts of Wine, or some othr Liquor, yt will not Freeze, to ye height F. Now wn ye ☿ rises att DE but one inch, it will raise ye liquor wch is pour'd in ye Tube KL an Inch; & ye slender Tube MP being of a much less Basis yn ye Tube KL, it must rise higher in MP. Thus if ye Basis DE be 10 times greater yn OP, for one inch yt ye Liquor rises in ye Tube KL, it will rise 10 inches in ye slender Tube MP. i.e. If ☿ falls one inch in ye Tube AB, ye Liquor will rise 10 in MP.

This sort of Barometer has also an Inconvenience; wch is, That as ye Weathr is Hot or Cold, so ye Liquor in ye Tube MP will dilate or contract it self, & conseq. rise or fall, whereas ye ☿ continues still ye same Height.

3. Since Mercury in a Tube keeps always ye same perpendicular height, however ye Tube be Inclin'd; The Best Contrivance for a Barometer seems This.

Fig. 3. ABC is a Tube, bended as in ye Figure; CB is abt 26 inches long, & AB so inclin'd yt it may be 15, whereas ye ⊥ AE wd not be above 5 acc. to ye Structure, For every inch ye ☿ rises in ye Ordinary Tube, it will rise 3 in ye Inclin'd one AB.

As Barometers show ye difft Changes of ye Air, as to Gravity & Levity, whence we Estimate Fair or Foul Weathr; So Thermometers are made use of to measure ye various Temperature of ye Air, as to Heat & Cold. To discover wch, yre are sevll Instruments contriv'd.

1. The First is almost in ye Form of a Barometer, only ye uppr end of ye Tube ends in a large Glass Ball; This Ball is Heated by putting near ye Fire, so yt ye Air in it will be rarified & somewt expell'd by Heat; yn immediately ye Neck of ye Tube is to be immers'd in Stagnt Water, wch shd be Ting'd wth some Color, yt it may more easily be perceiv'd.

Fig. 13. As ye Air in ye Ball A begins to cool (it being more rare & less compress'd yn th' External Air) ye Water in ye Vessel will be impell'd up into ye Tube to B by ye force of ye External Air, & so compress ye Air att A, as much

Plate 6. } as ye Externall air is compress'd. now if ye air in A be afterwds (54
Fig. 13. } again more heated, it will endeavor to expand it self, & fill up a greater space, & so press ye Water down: But wn it grows cooler it will be contracted into a less Compass, & ye Watr will again ascend. So yt wn ye Watr in ye Tube descends, ye air is Hotter; wn it ascends, Cooler.

2. The Second kind of Thermoscope is by a Recurve Tube, thro' ye Orifice of wch
Fig. 1. } att D ye Ting'd Water is pour'd, & fills up ye Space BC, compressing ye air in ye Globe A; in wch, wn ye air grows more hott, it expands it self & takes up greatr room, by pressing ye Watr in ye Tube upwd att D; & wn ye air is cool'd, it is again condens'd, & ye Water falls down: So yt ye rising of ye Water denotes ye Heat, & its falling ye Coldness of ye air, Contrary to wt is done in ye First Sort.

3. The Third Sort is in This Fashion. Thro' ye narrow neck of a Glass bottle fill'd wth Watr is putt a long Tube open att both ends; ye lowr end of
Fig. 12. } wch is imers'd below ye Water. After having fix'd ye Tube wth Cement, so yt yre can be no Comunicacon betwn ye Externall air, & yt in ye Phial; air is blown strongly thro' ye Tube, by wch ye air in ye Phial is Compress'd, & yrefore it will press ye Water up to D: And if ye air always continu'd in ye same Tenor as to Heat & Cold, ye Water wd always continue in ye same Station; But wn ye air in ye Phial grows hottr, it will endeavor to expand it self, & press more strongly on ye Surface of ye Water, & raise it highr in ye Tube.

In these & all other Sorts of Thermometrs, yt have any Comunicacon wth ye Externall air, ye Liquor will not only be depress'd or rais'd by ye change of air as to Heat & Cold, but also by any alteracon as to Gravity & Levity; & conseq. ye Temperature of ye air as to Heat & Cold may remain, wn nevertheless ye height of ye Watr may be considrbly altered.

4. This Sort of Thermoscope yn is not liable to ye same In= convenience: It is a Long Tube wth a Glass Ball att ye End of it, wch being fill'd wth high Rectified Spirits of wine half full up
Fig. 5. } to D, ye remaining part of it is considerably heated att C, yt ye air may be expell'd; after ys, ye Top of ye Tube is imediately to be Seal'd Hermetically, so yt ye air may not reenter ye Tube; Then ye Rarefaction & Condensacon of ye Spt of Wine, by wch it rises or falls in ye Tube according to ye degrees of Heat or Cold, shew ye Temperature of ye air as to Heat & Cold.

5. Another sort of Thermoscope is thus contriv'd: A & B are 2 Cylindriacal
Fig. 14. } Glass Vessels joyn'd to ye Recurve Tube EGF; ye upper pt of ye Vessel A is void of air, & ye rest is fill'd wth ☿ as in ye Torricellian Experimt, & ye ☿ rises half way in ye Vessel B; on ye Surface of ye ☿ yre is putt in a Tube some Ting'd Liquor, or rathr Oil of Tartar
per

Fig. 1.

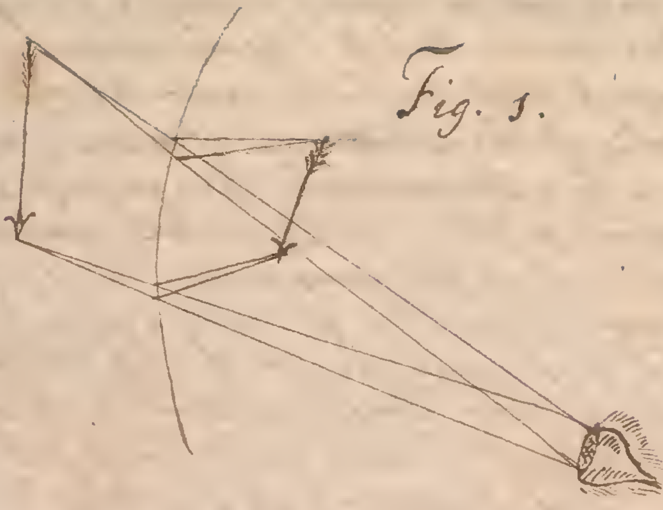


Fig. 3

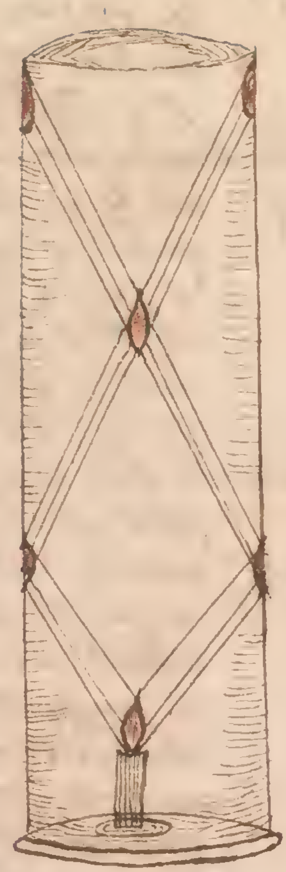


Fig. 2

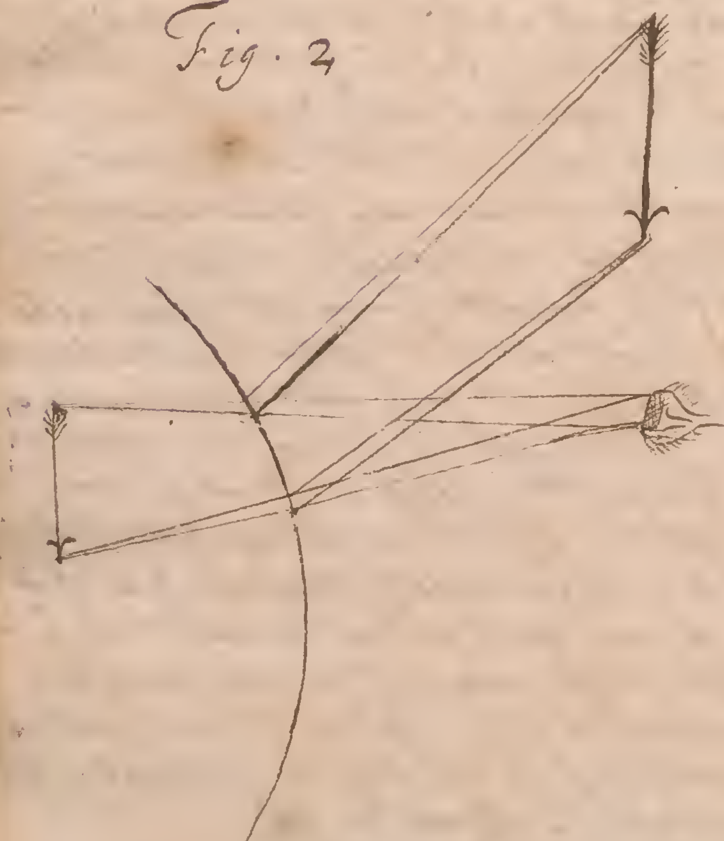
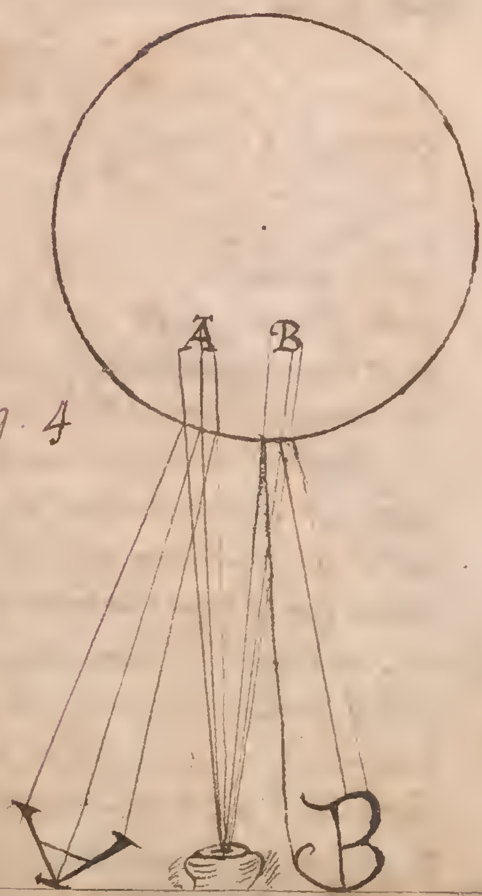


Fig. 4



per Deliquiū, wch will not freeze, & reaches up to D; to ye End
Plate 6, Fig. 14. of ye Tube BK a Glass Globe C full of Air is seal'd on Hermetically to prevent Comunicaĉon wth ye Externall air. In ye Thermometer, wn by ye Cold of ye Ambient Air, ye Air in C is cool'd & condens'd, ye ☿ will by its own Weight subside in A & rise higher in B, & conseq. impell ye Liquor up into ye Tube BK. And if ye Basis of ye Cylindriacall Vessels A & B be 10 times greater yn ye Basis of ye Tube BK; wn ye ☿ falls one Inch in A, or rises one in B, ye Liquor will rise 10 inches in ye Tube BK: Also if ye Air be heated in C & rarified, it will by expanding it Self make ye ☿ descend in B, & rise in A; So yt ye Smallest Variaĉons as to Heat & Cold are thus shown by ye Ascent & Descent of ye Liquor in ye Tube BK.

To Measure ye Moisture & Dryness of ye Air, we use an Instrumt call'd an Hydrometer, of wch yre are 2 or 3 Sorts.

1. The First is made by a Fine Balance, in one of ye Scales of wch is putt a peice of Spunge, & in ye other a Wt to counterpoise it; ye Spunge in Damp Weather imbibes ye Moisture & becomes heavier, in Dry weather, ye moisture being exhal'd, ye Spunge grows lighter; & so by ye Moĉons of ye Examen, we find ye Alteraĉons of ye Air in respect of its Humidity. To make ye Variaĉons more Sensible, ye Examen of ye Balance is made very long, wch passes on a Circular Arch of Brass divided into degrees, & mark'd 1.2.3.4.&c. and acc. as ye End of ye Examen is att any of ye degrees, so we Judge of ye Weather. (Plate 4, Fig. 11.)

2. Another Sort is contriv'd after yt Manner: To a Rope or Cats-gutt a Cylindriacall Wt is tied; In Damp Weather, ye Rope by twisting it Self will contract & pull up ye Wt, & in Fair Weather lett it Sink farther down. To make ye Variaĉons more Sensible, ye Cylindriacall Wt being abt 15 or 16 inch round, is divided into 30 or 40 equall pts mark'd 1, 2, 3, &c. To prevent its being injur'd, a Glass is putt over it, thro' wch ye String passes att A; ye Glass is cover'd wth Brown or Blue paper except one Small hole, thro' wch ye Figure on ye Side of ye Wt may be seen: Now ye Twisting or Untwisting of ye Rope, acc. to ye Variaĉon of ye Moistness of ye Air will always present a new figure to ye Hole. (Plate 6, Fig. 2.)

3. A third Sort of Hydrometer is made wth ye Beard of a Wild Oat, or ye Husk of a Small Vetch, wch in Dry weather twists, & in Wett untwists. One End is fasten'd to ye Bottom of a Box, ye other comes thro' a Hole in ye Lidd & has an Index adapted to it; So yt ye Moĉon of ye Hand or Index on ye top of ye Box shews ye Variaĉon of ye Moistness & Dryness of ye Weather.

Catop

In ye Foregoing Page 17,

Fig. 1st shews, yt ye Image of an Object reflected fm a Concave Mirrour (ye Objt being plac'd wthin ¼ of ye Diameter fm ye Centre or Vertex) appears behind ye Glass, larger, & farther off.

Fig. 2d shews, yt ye Image of an Object reflected fm a Convex Mirrour, appears behind ye Glass, Less & nearer yn ye Object.

Fig. 3d shews ye Image of a Candle, enclos'd in a Concave reflecting Cylinder, as it is reflected fm ye Sides, & appears in ye middle.

Fig. 4th shews how a Distinct Image is form'd of any confus'd Object, being reflected fm ye outside of a perpendicular Cylindriacall Mirror, as ye 2 letters A B from A B.

All fm 2 generall Rules, 1. That ye Angle of Incidence is equall to yt of Reflection. 2. That both of 'em are in ye same plain ⊥ to ye Reflecting Body.

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† A Reall Focus is ye place, where ye Rays actually meet

Plate 7, Fig. 5. } as ye point B, where ye Rays D meet after they have pass'd ye Glass CC: And ye point A, where yose Converging Rays wd meet, if yre was no Glass CC, is call'd ye Imaginary Focus.

In a Concave Mirror, if C be an Object, E will be ye Focus of

Fig. 8. } ye Rays, wch having diverg'd fm ye Object & fall'n upon ye Concave Mirror, are by Reflection made to Converge at E.

A Concave Glass Transmitting hath no reall Focus of Parall Rays, because after they have pass'd ye Glass, they Diverge

Fig. 3. } fm each other; as ye Rays A, after they have pass'd the Glass E, diverge towds D: But ye point C is call'd ye Virtuall Focus of ye Concave Glass.

* It is ye same, wch of ye Angles (either yose or yt are nearest ye ⊥, or those next ye Plane) we call ye Angles of Incidence & Reflexion, wn they fall on a plain Surface; because ye Equality of either are alike easy to be demonstrated. But on a Concave or Convex Surface, it being much easier to measure & discern ye Equality between ye former, yn ye latter (viz. by raising a ⊥ to ye Tangent on yt point ye Ray falls on) therefore ye Angles adjoining to ye ⊥ being more generally observable, we chuse to give yose ye name of

Fig. 2. } ye Angles of Inc: & Refl: as ABC & DBC.

✠ The Angle

Catoptricks.

Definitions. 1. Rays of Light are Those, wch are diffus'd every way in Straight lines thro' ye Same Medium, & spread ymselves constantly after ye same Tenour, as long as they continue in ye Same Mediu͞.

2. A Radiant is yt, fm whose points Rays spread ymselves every Way.

3. Diverging Rays are those, wch meet (or produc'd meet) in a point opposite to ye Direction of yeir Moco͞n; Or those Rays, yt spread ymselves after yt manner, as if they had all come fm one point, whether Really they do come fm yt Point or not. As ye Rays going fm B to D, are said to Diverge fm ye point C, whethr they actually come fm it, or not; for tho' they shd come fm A, they're said to Diverge fm C, because if you produce 'em fm B, till they meet in a point opposite to ye Direction of yeir Moco͞n, yt Point will be C.

Plate 7 } Fig. 3. }

4. Converging Rays are those, wch meet in a point towds yt part, whithr ye Direction of yeir Moco͞n tends; As ye Rays DB are sd to Converge towds C, whethr they meet in C, or after Refraction thro' ye Glass EF they go on parallel to ye Line ACD.

Fig. 3. }

5. † The Focus is yt Point where ye Rays meet.

6. Parallel Rays are those, wch come fm a point att a great distance from us & contain but a very small angle one wth another, as fm ye Sun.

7. Rays are said to Reflect, wn they're turn'd backwd in ye Same Mediu͞.

8. The Angle of Incidence, is yt wch is contain'd under ye Incident Ray & ye ⊥ to ye plain att ye point of Incidence, as ABC.

Fig. 2. }

9. The Angle of Reflection is yt wch is contain'd under ye Reflected Ray & ye sd perpendicular, as ye Angle DBC.* Sometimes ABE & DBF are call'd ye Angles of Incidence & Reflection.

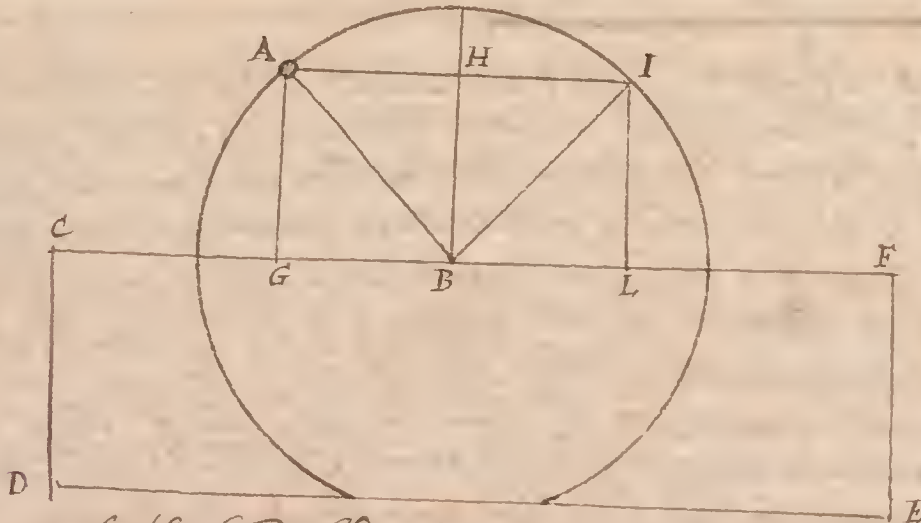
Theorem. The Angle of Incidence is always Equall to yt of Reflection: This is confirm'd by Experience & has been seu^l ways Demonstrated by Mathematicians.

10. Specula or Mirrors, are these, wch, by Reflecting ye Light, form Images of Externall Radiants.

Theor. Rays coming fm a point A, & falling upon a plain Mirror BC, after Reflection Diverge fm ye point a, wch is in ye ⊥, as far behind ye Glass, as ye Radiant is before it. For because AB is equall to aB, & DB common to both ye Triangles ABD & aBD, & ye angles att B are equall; ye angles ADB & aDB will be Equall (p l. 1. prop. 4 Eucl. El.) But (by ye

Fig. 1, 4. }

1 ✠ The Angle of Incidence is always Equall to yt of Reflexion As Demonstrated by Rohault, part 1 c. 15.



Lett A a perfectly hard body (as a Globule of Light) moving in one strait line AB fall upon a perfectly hard Body CDEF,
1 Cor. to wch comunicating none of its Mocon, A must continue to move; tho' meeting wth this repulse, it must be in anothr direction. Which To find; from ye Centre B, att ye distance AB, describe a Circle; and because in a certain space of time A has mov'd fm ye Circumference to ye Centre of yt Circle, in ye same time it ought to return to some one point in ye Circumference again. Fm ye points A & B draw ye Right lines AG & BH ⊥ to ye plane CF, & ye line AHI ∥ to ye same plane. Now tho' ye mocon of A be single, its Determinacon is compounded of 2; viz. one fm A to H, th'other to G; ye lattr of wch is obstructed by ye Body CDEF,
2 Cor. but ye former not, so yt it must go on ye same; and as in a certain space it came fm ye line AG to ye line HB, in ye same space it ought to move fm thence to a point in ye line IL (a line I suppose drawn ⊥ to ye plane CF, & equally distant fm HB, as HB fm AG) But, to satisfy ye whole mocon, we show'd yt A ought to move to some one point in ye Circumference of ye Circle; & now, to satisfy yt pt of its Determinacon, wch was never obstructed (viz. fm A to H, & so on) it must come to a point in ye line IL: Therefore to satisfy both att ye same time, ye Body A must be found in ye comon point I, & have been reflected back fm ye Body CDEF in ye line BI; wch Line wth ye Surface, makes an Angle of Reflexion IBL equall to ye Angle ABG of Incidence. For BL = GB by Supposition; & LI = GA, because GL & AI are ∥; & ye angles L & G Right angles by Supposition; Therefore ye 2 Triangles ILB AGB are Equall & Similar, & conseq. ye angle IBL = ABG. Q. E. D. *

* Or if ye inner Angles next ye ⊥ be accounted ye Angles of I. & R. By ye same construction ye Angle ABH is prov'd equall to ye Angle IBH; For, by construction, HB was ⊥ to CF, so yt ye 2 angles GBH & HBL being Right are also equall, of wch yr parts ABG & IBL have been prov'd equall; ye remaining pts ABH & HBI are Equall also. Q. E. D.

From ye

15 prop. of ye same) ye Angles ADB & GDC are Equall: Therefore (57)
if AD be ye Incident Ray, GD will be ye Reflected. After ye same man-
ner it may be shewn, yt HE is ye reflected Ray of ye Incident AE, &
Plate 7, Fig. 4. } KF of AF; & therefore all ye Reflected Rays, if produc'd, will meet
att a. If ye Eye were plac'd att H, it wd receive ye Rays, wch come
fm A & are Reflected att ye Surface BC, as if they had really come
fm a; & conseq. ye Eye will be ye same affected, as if it were att
O & receiv'd ye Rays coming fm A; & Therefore ye Eye att H will see
ye Image of ye point A att a.

Since ye Image of every point is as far behind ye Glass, as ye Point is
Fig. 6. } before ye Glass, ye Image must be ye same way Inclin'd to ye Glass,
as ye Radiant is; So ye Image of ye point A must be att a, of E att e.

Hence it follows yt if ye Glass lies Horizontally, Objects will have yeir Ima-
ges inverted, & Men will appear wth yeir Heads downwd, as wn we look
into ye Water.

Wt has been shown of ye Principall Radiants, is also True of yeir Ima-
ges; for they may be consider'd as Objects wch Send Rays, & yrefore
if yre be anothr Glass to receive ye Rays, yre will be anothr Image
form'd wthin yt Glass, & so yt Image still will have anothr Image &c.
Whence arises ye Multiplicacon of Images by 2 or 3 plain Looking-
Glasses.

Suppose 2 Looking-Glasses BC EF; let ye Radiant be A, whose
Image by ye Glass BC is a; This Image being consid. as a Radiant
Fig. 7. } will send Rays to ye Glass EF att α; & yt Image will likewise have
its Image in ye Glass BC att G, & so you may Multiply Images,
as far as you please.

If GD, HE, KF be Incident Rays, their Reflected Rays will be DA, EA, FA;
Fig. 4. } i.e. If Rays be converging to ye point a there to Form an Image, & yre
be interpos'd a plain Speculm BC, they will reflect to ye point A,
& form an Image yre. Experience answers This exactly.

Take a Comon Reading or Burning Glass E, & put ye Radiant att A, lett
ye place of ye Image to be form'd be a, put a Looking-Glass att BC,
Fig. 9. } And a Mans Eye att O will see ye Image att a in ye air betwn him
& ye Glass; For by ye Burning-Glass ye Rays coming fm a point in
ye Radiant A, are made to Converge to a Correspondent point in ye Im-
age α, but by ye Looking Glass they are intercepted & Reflected;
therefore they'l turn anothr way, & yose yt went fm one point att A
will meet wth anothr correspondt to it att a, where they'l form an Image.

In Concave Spharical Mirrors, ye Image of a point is always in a line
passing thro' ye point & ye Centre. Thus ye Image of ye point E will
Fig. 10. } be att e, ye Image of ye point F att f, & of G att g.

Hence

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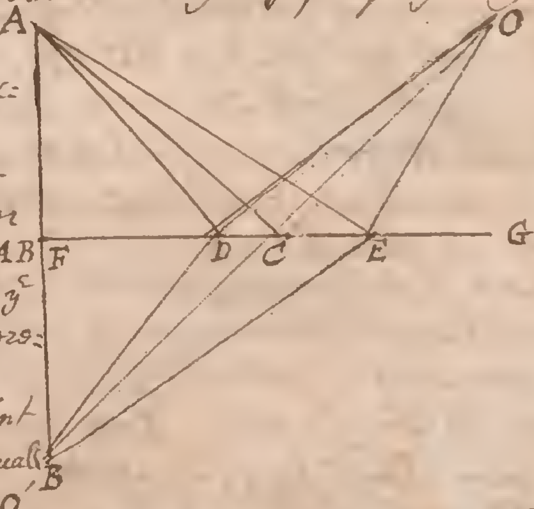
From ye foregoing Demonstracon, may be drawn these 2 Corollaries,

Cor. 1. That ye Reflected mocon is no new mocon arising fm ye Elasticity of either Body, but only a continuation of ye Direct mocon, wch otherwise wou'd be lost.

Cor. 2. That ye 2 Lines of Incidence & Reflection lie both in one & ye same plane, wch plane is perpendicular to ye Surface of ye Reflecting Body. Because, tho ye Determinacon of ye Body A towards G be obstructed by ye Body CDEF, yet its Determinacon tow'ds I being not chang'd, yre is no reason it sh'd deviate fm ye plain ABI.

S. Clarkes Annot. ad Roh. p.1.c.15.

Since Nature is confess'd to work always ye Shortest way, and Light esp. if not obstructed, is propagated in straight i.e. ye Shortest lines; It may serve to confirm this Demonstracon, To prove yt ye Equality of ye 2 fore-mention'd Angles is ye shortest way of propagating Light.



An Image att A being reflected fm some one point of ye plain Speculw FG, is seen by ye Eye att O.
1st Suppose it reflected fm ye point D, so yt ye Ang: of In. ADF be greater yn ye Ang: of Refl: ODG (the line AB being drawn ⊥ to FG & AF = FB) ye *line AD may be easily prov'd = DB, wherefore BD + DO = AD + DO.

* 4 prop. 4 lib. 1. Eucl.

2ᵒly Supposing it reflected fm ye point C, so yt ye Angles of I. & R. wd be Equall, in like manner BC + CO = AC + CO.
3ᵒly Supposing ye Reflexion made on ye point E of ye Speculw FG so yt ye Angle of I. be less yn ye Angle of R; by ye same means BE + EO may be prov'd = AE + EO: ‡But it is plain, yt BCO being but one side of a Triangle is less yn either BD + DO ye 2 sides of one Triangle, or yn BE + EO 2 sides of another Triangle; Therefore, by wt was prov'd before, it is plain, That AC CO are less yn AD DO, or yn AE EO; And Conseq. That ye Angles of Incidence & Reflection being equall is ye Shortest way in wch Light or any othr Body can be reflected. Q. E. D.

‡ prop. 20 lib. 1. Eucl.

Hence it follows yt if ye Image be in ye Air before, it will appear (58
Inverted; the Reason why ye Image is form'd thus is, because all
Plate 7. Fig. 10. ye Rays wch come fm ye point E & fall near ye Vertex of ye Mirror Reflect, so yt they will meet att e, whence they Diverge forming att e ye Image of ye point E: after ye same manner, those wch come fm F, after Reflection will meet again att f, & yn form ye Image of F; as like ye coming fm G, att g.

If ye Radiant approaches ye Glass, ye Image will recede fm ye Glass, & att ye Centre of ye Sphere they will both meet.

If ye Radiant approaches still nearer, ye Image will go out beyond ye Centre; & wn ye Radiant comes to be att ye Distance of $\frac{1}{4}$ of ye Diameter fm ye Vertex, ye Image will be out att an Infinite distance; wn ye Radiant comes nearer to ye Glass yn $\frac{1}{4}$ of its Diameter, ye Image appears behind ye Glass & erected.

If ye Mirror be Convex, ye Image of an Externall Radiant is always behind ye Glass.

The Magnitude of ye Image may be known fm ys: That it always appears under ye same Angle fm ye Vertex of ye Speculum, yt ye Radiant does; & Conseq. they will have ye same proportion to one another, yt their Distances fm ye Vertex have. And therefore if ye Radiant be farther off, yn ye Image, fm ye Glass, it will be Bigger yn ye Image; if att ye same distance att ye Centre they are Equall; if ye Image is farther off yn ye Radiant fm ye Glass, it will appear Bigger yn ye Radiant. Thus in ye Figure, E may
Fig. 8. be ye Radiant & e ye Image, or e ye Radiant & E ye Image.

N.B. The Focus, or point where ye Image is found, is ye middle point between ye Vertex & ye Speculum, in all yse cases, where ye Radiant is supposd att an Infinite Distance, as ye Sun; & ye Rays sent fm it are reckon'd as Parallel.

Dioptricks.

When a Ray of Light comes out of one Medium into another, it changes its Direction. This Changing of Direction is wt we call Refraction.

The Angle of Refraction is comprehended under ye Refracted Ray & a ⊥ drawn to ye Surface of ye Refracting Medium, and att ye point where
Fig. 12. ye Incident Ray falls on ye same Medium, as ye Angle HDK; If ye Ray of Light goes into a Thicker Medium, it comes nearer to ye ⊥, if into a Thinner, it recedes farther fm it.

There are Severall ways to show ys By Experience. (v.g.) Take a Basin, into wch putt a peice of Money att A, & yn Recede so far back, yt ye sides of ye
Fig. 11. may intercept ye sight, so yt Light cannot come in a Straight Line fm A

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♀ A plain Instance of This Refraction is ye Sun, wch we see for some time, after 'tis really descended below our Horizon, being refracted thro' ye Atmosphere & Vapours intermix'd wth ye air next surrounding us. Barthol. c. 7.

♈ Since a Heavy Body (stone or ye like) falling out of a Thinner Mediū into a thicker, as out of air into water, is always Refracted fm ye $\perp$, & vice versâ; It may be doubted how it comes to pass yt Light shou'd have just a Contrary refraction, viz. in passing fm a thinner into a thicker mediū Towds ye $\perp$, & vice versâ. But It is to be observ'd, That ye Direction of ye Refracted Body is always chang'd either To, or From ye $\perp$, according as ye Body in passing thro' meets wth more or less Dificulty & Resistance; so yt a stone may easier break thro' ye parts of air yn of water; and yet Light, wch is so fine a Body, can wth much greater facility pass thro' water yn air, Because Light has no need to separate ye parts of any Body but only pass thro' ye Pores, wch are always more open & free ye Firmer any Body is (so yt Glass is more easily penetrated yn Water, & Chrystall yn Glass) Whereas any Hard large Body is to separate ye parts of ye Mediū wth its main Force, or else it cannot be transmitted.

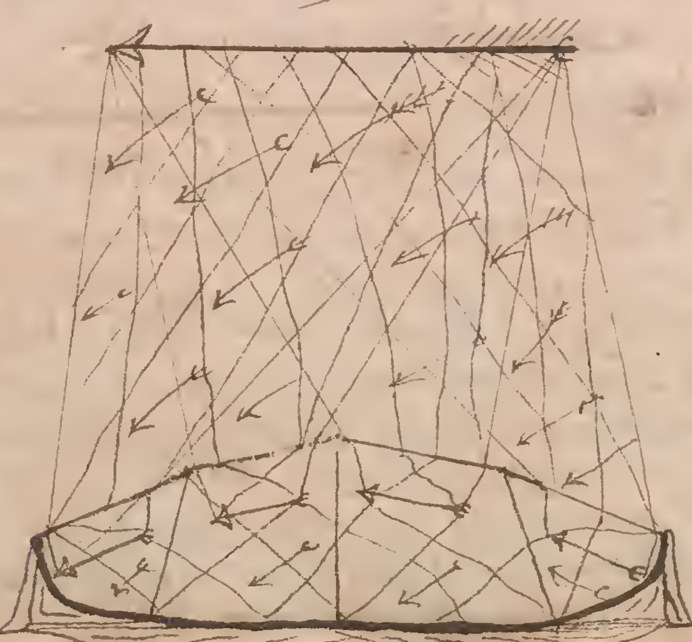


Plate 7, } A to ye Eye att D; if Water be afterwds powred in, ye Money will (59
Fig. 11. } be seen; For ye Ray AB, wn it comes to ye Surface of ye Air att B, changes its Direction, & goes off in DB, & so Enters ye Eye. ♀

Suppose ye Mediu EC to be air, HK Glass or Water, & AB ye Surface of ye
Fig. 12. } Mediu HK; Lett ED be a Ray of Light entring ye Mediu at D, as ye Angle EDC is ye Angle of Incidence, So is HDK ye Refracted Angle and ye Lines of ye Angles have always a certain Determinate pporcion to one anothr, & if you take Small angles they yrselves are always in ys pporcion; If EC be air & HK Glass, ye angle EDC is to HDK, as 3 to 2; If EC be Air, & HK Water, ye pporcion is yn 4:3.

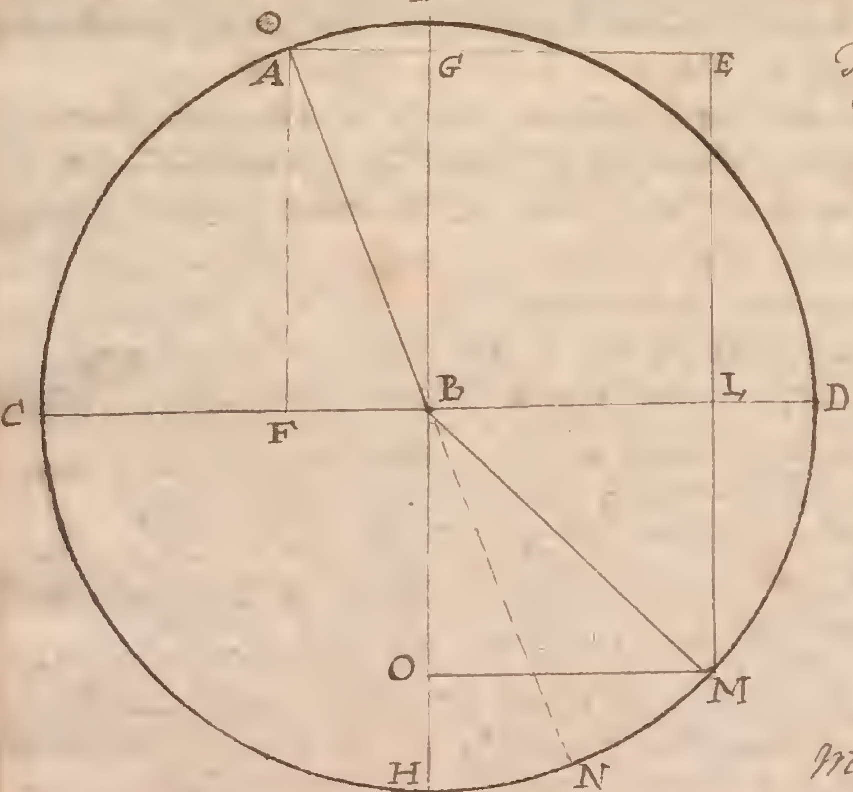
To show Refraction more plainly, Take a Comon Burning Glass, & cover
Fig. 13. } it wth paper, in wch lett yre be 2 Holes, thro' wch ye Light is to pass att B & C, yn putt a Candle att A; If ye Light pass'd thro' without Bending, ye Rays coming thro' ye Holes B C ought to diverge farther & farthr fm one another, But we find yt if ye Lt be recd upon a peice of paper, ye Rays converge one to anothr wn ye Paper is att I, ye Light falls fm GH; wn tis remov'd farthr to K, ye Rays fall to DE nearer one anothr; & wn ye Paper is remov'd to F, yeir 2 Lights coincide, & yn diverge again.

Suppose GH Water & IAF air, ye Rays coming out of Water into Air are Refracted, So yt Those wch come fm ye point E, seem after
Plate 8, } Refraction as if they had come fm C, & enter ye Eye att IA, as
Fig. 4. } if they had all come fm yt point; so yt CE is $\frac{1}{4}$ of BE.

Hence wn We look on an Object in ye water, it appears $\frac{1}{4}$ nearer ye Surface yn it is; & on ye same acct an Oar in ye water will
Fig. 3. } appear Bent, for ye point A will appear higher viz. att B, & ye point C att D, So yt ye Oar in ye Water, instead of being seen in ye Position FCA, will be seen in yt of FDB.

If ye Object A be seen thro' ye Prism GH by ye Eye att D, it will appear as if it was att C; for ye Rays falling fm A obliquely
Plate 10, } upon ye Surface of ye Prism att H Refracted towds ye ⊥,
Fig. 6. } (because they go fm Air into Glass) & wd go on in ye Direction HG still, if yey continu'd to move in Glass; But emerging att G out of Glass into air, they are Refracted fm ye ⊥, & going on in ye middle line DG, enter ye Eye, as if they directly fm C.

If ye same Object be seen thro' a Mediu wch is terminated by many Plain difft Surfaces, it will appear to be multiplied, into as many, as yre are Surfaces; for thro' every Surface ye Objt
Plate 8, } is seen in a different place, & consq. as many Surfaces as yre
Fig. 2. } are, so many distinct Objts will appear; ye Rays, wch come fm ye



The Angle of Refraction either To, or From ye $\perp$ is greater or less proportionably acc. as ye Body passes thro' one medium into another wth greater or less Ease as to ye former sort of Refraction; or wth greater or less Difficulty, as to ye latter.

Rohault part. 1. c. 15.

To Demonstrate in what Manner Refraction is made;

Above ye line CD suppose a Medium of Air, below it of Water, Lett ye water have double ye Resistance of Air; Let a Ball fall fm A to B, in ye line AB in ye Space of one minute, therefore, ye Resistance of ye water being double, in 2 minutes it will go ye same length, viz. fm ye Centre B to some one point in ye Circumference of ye Circle. Now ye single direction of A being made up of 2 Determinacons, one $\parallel$ to G, ye other $\perp$ to F; & ye latter only suffering fm ye Resistance of ye new Medium; therefore A in its former Determinacon, in double ye time, must go double ye length it did before, i.e. ye line GE to E, wch is double AG; But in its latter (as was sd before) it must go ye same length in double ye time, viz. to ye Circumference of ye Circle: Therefore to satisfy both Determinacons, A must come to such a point in ye Circumference, as will exactly answer E, i.e. to M. So yt as ye direct Mocon of A shd have been to N, by Refraction it recedes fm ye $\perp$ as far as M, & ye Angle MBN is ye measure of ye Refraction, so yt ye whole Angle HBM is just double ye Angle HBN, proportionably, as ye Resistance of ye lower medium was double to yt of ye upper.

By wt has been said, it appears that if ye lower medium had as little again Resistance as ye upper, ye Refraction had been just as much to ye $\perp$, as now it receded fm it. So yt ye Angle &c Q. E. D.

* Isaac Vossius has observ'd yt this middle Ray or axis (is in some measure Refracted into it self & shrivel'd up.)

Voss. De Naturâ Lucis cap. 16.

fm ye Objects thro' ye Different Surfaces of ye Glass, for=ming ye Images yrein on severall parts of ye Retina.

A Lens is a Glass, wch is terminated by 2 Sphericall, or by one plain & one Sphericall Surface. And it is Convex on Both sides or Convex on one side & plain on ye other; Concave on Both sides, or Concave on one side & Flat on ye other; Or a Menis=cus, yt is, Concave on one side Convex on ye other.

When Rays diverge fm any point of an Object, & spread ymselves every way; if you expose a Convex Lens to yose Rays, they will form a

Plate 10, Fig. 5. Cone, whose Vertex is att ye point of Divergence, & Base att ye Lens; as ye Rays wch diverge fm A & fall on ye Glass CD: wn ye Rays pass thro' ye Glass, they are all Refracted (except yt wch falls att E in ye middle of ye Glass) & meeting again att ye point B, form another Cone, whose Base is ye Glass CD (on ye other side) & Vertex att B; This Cone together wth ye other Cone is call'd a Pencil of Rays, & AEB is ye Axis of yt Pencil, or a Line drawn fm ye point of Divergence on one side of ye Glass to ye point of Convergence on ye other. as many Pencils of Rays pass thro' a Glass, as yre are visible points in ye Object, & tho' ye Axes of ye Oblique Pencils suffer some Refraction in passing obliquely thro' ye Lens, yet they are not to be look'd upon as Refracted; because after they have pass'd ye Glass, they go on in a Line parall to ye line, in wch they mov'd, before they entred it, & ye Thinner ye Glass is, ye more insensible is yt Refraction.

Plate 8, Fig. 1. Aa Bb Cc represent 3 pencils of Rays passing thro' a double Convex Glass. Wn ye Object ABC by means of a Double Convex Glass, has its Image projected att cba; ye Angles, wch ye Axes of yose Pencils, yt come fm ye Extremities of ye Object, make wth ye middle of ye Glass, determine ye Magnitude of yt Image; & ye place, where ye pencils of Rays terminate on yose Axes, is called ye Distinct Base, because there only is ye most Distinct Image of ye Object projected. All ye Rays wch come fm ye point A will after Refraction be made to converge att a, & all ye Rays wch come fm B, will after Refraction meet att b, & all ye Rays wch come C, will be refracted to c. And if ye Eye be att a it will receive ye Rays diverging fm abc ye same way, as if it had receiv'd ym directly coming fm ye Principall Radiant ABC, & yrefore ye Image will be form'd att abc, & inverted.

If a peice of paper be plac'd att abc, ye Rays will ynce be Reflected by ye paper, & will paint on ye paper ye Image of ye Radiant.

The Image & ye Radiant have always ye same pportion one to anothr as yeir Distances fm ye Lens has: & yrefore, If ye Image be farthr fm

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Plate 8. Fig. 1. fm ye Lens yn ye Radiant is, it will be bigger yn ye Radiant; 61
if nearer, it will be Less; If ye Radiant att ABC be brought nearer
to ye Lens, ye Image will recede farther fm it; & it may be brot
to such a determinate distance, as to cast ye Image as far fm ye
Glass, as may be requir'd to magnify it to any giv'n proportion.

If ye Glass be equally Convex on both sides, & ye Radiant plac'd att a Semidiameters distance fm ye Lens, ye Image is cast out att an infinite distance; & if ye Radiant be plac'd att an infinite distance, ye Image is at a Semidiameter's distance fm ye Lens.

If ye Sun be ye Radiant, (wch is att an infinite distance) & ye Glass be sufficiently broad, in ye place of ye Image, yre will be a Flame, wch will burn very intensively, because all ye Rays wch come directly fm ye Sun, & fall on ye broad Lens, are by Refraction brought into a small place to form ye Image.

If att ye place of ye Sun's Image (wch is sometimes call'd ye Focus of parall Rays, & sometimes simply ye Focus) yre be plac'd a Lucid

Fig. 6. Body, as a Candle or Lamp, ye Rays after Refraction will go out parall & not Diverge fm one another; & ye Light not spreading will continue in ye same Intenseness at all distances, & conseq. will Illuminate all objects att a distance.

On This principle all Convex Lanthorns are made.

If ye Radiant be nearer ye Lens yn ye Focus of ∥ Rays, ye Image will not be seen on ye other side of ye Lens, but on ye same side yt ye Radiant is, only farther off & not Inverted, but Erect.

Suppose ABC a Radiant nearer to ye Lens, yn ye Focus of Parall Rays,
Fig. 5. all ye Rays, wch come fm ye point A, will enter ye Eye at E, as if they had come fm ye point a; & all ye Rays wch come fm B & C, will seem to have diverg'd at first fm ye points b & c; so ye Eye will see ye Object, not att ABC, but abc: & because ye Angle AEC is ye same wth ye angle aEc, ye Object will be seen magnified, abc being greater yn ABC.

If a Room be darken'd, & only one Hole made in ye Window, to lett in ye Rays wch come fm Externall objects, & in ye Hole yre be placed a Convex Lens; ye Lens will form ye Images of all externall objects, wch are before it, & if att a distance yre be putt a peice of white paper, ye Images will be receiv'd on it, & they'll all appear Inverted. The Reason of wch follows clearly fm ye Principles; for all Rays wch come fm any one point of ye Object, will by Refraction be made to meet att one point on ye paper, & yence they'll be reflected again: & ye same thing is true of every other point; so yt ye Image of every point thus put together on ye paper, will shew ye Image of ye Radiant Object, in ye same Colour ye Object is of; because every Image is form'd by ye very same Rays, & of ye

of ye very same affection as to Colour, as they wch come fm ye (62
Objects are. The Objects being much farther fm ye Lens yn ye Images are, ye must be far less; & ye nearer ye Object is to ye Lens ye Images will be farther fm it, & appear bigger. If ye Object move, ye Image will also seem to move, provided it do not move directly tow'ds ye Lens. By This principle ye Prospect of Places may be taken

The Appearances of ye Magick Lanthorn differ but little fm those of ye Dark Chamber. The Lanthorn has 2 Convex Glasses att A & BB, & a Lamp burning at E, DC is a long peice of Wood in wch are cut sevl round holes to hold ye pictures wch are of painted Glass; & ye Flame of ye Candle or Lamp being great, a considerable Quantity of Light falls on ye Pictures, & passing thro ye 2 Lens's will form ye Images of yose Pictures on ye Opposite Wall. The pictures being much nearer to ye Lens, yn yeir Images on ye wall, ye Images will be much larger yn ye pictures acc. as ye Wall is distant. If by pulling out ye Tube in wch ye Lens B is fix'd, you make ye Distance of ye pictures greater, ye distance of ye Images will be less, & conseq. ye Images ymselves less in propor=tion

Plate 7, Fig. 14.

A Concave Lens forms ye Image on ye same side, yt ye Radiant is, but much less & nearer it. For if ye Object AB be put before ye Lens EF, it will be seen by ye Eye att C, in ye position $\alpha\beta$, & by consequence, less yn ye Object; For ye Ray AE falling on ye Lens att E, is refracted into gE, & comes nearer ye ⊥, & ye Ray Eg coming on ye Concave Surface of ye Air at g, will be refracted into gC, & recede fm ye ⊥; so yt ye Ray gC will enter ye Eye att C, as if it had come directly fm α, & not fm A, so yt ye Eye being at C & receiving ye Rays wch come fm A, will be ye same affected as if it had come fm α. After ye same manner, ye Ray's wch come fm B will enter ye Eye att C, as if they had come fm β: So yt ye Eye will see ye Objt AB at $\alpha\beta$, nearer to it, & much less yn it is.

Plate 8, Fig. 13.

The Eye is a Lens contriv'd by God to project ye Images of Externall Objts on ye Retina, & then it is, yt we see distinctly, wn the Images are painted on ye Retina. Immediately under ye first Coat of ye Eye, wch is call'd Tunica Cornea AB, yre's an Humor of ye same Consistence wth Water, & is call'd ye Aqueous Humour EF; In ye Midst of yt yre swims anothr membrane call'd ye Uvea CD, wch is Opake, & letts no Light pass thro' it, but it is perforated att CD, & ye small hole is call'd ye pupilla, so yt all ye Light, wch forms ye Image, must pass thro' yt Hole; next to ye Watry Humor is a Consistent Globe, wch is call'd ye Chrystalline Humor K; & behind ys is plac'd ye Vitreous Humour GH, wch is not Consistent as ye Chrystalline, but yet is firmer yn ye Aqueous. Behind ye Vitreous humor lies ye Retina, wch arises fm ye Insertion of ye Optick Nerve at L, & is suppos'd to consist

of ye very same affection as to Colour, as they wch come from ye (62

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Plate 7,
Fig. 14.

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Plate 8
Fig. 13

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Fig. 8.


Plate I.

line Humor K; ... Vitreous Humour ..., wch is not Consistent as ye Chrystalline, but yet is firmer yn ye aqueous. Behind ye Vitreous humor lies ye Retina, wch arises from ye Insertion of ye Optick Nerves ...

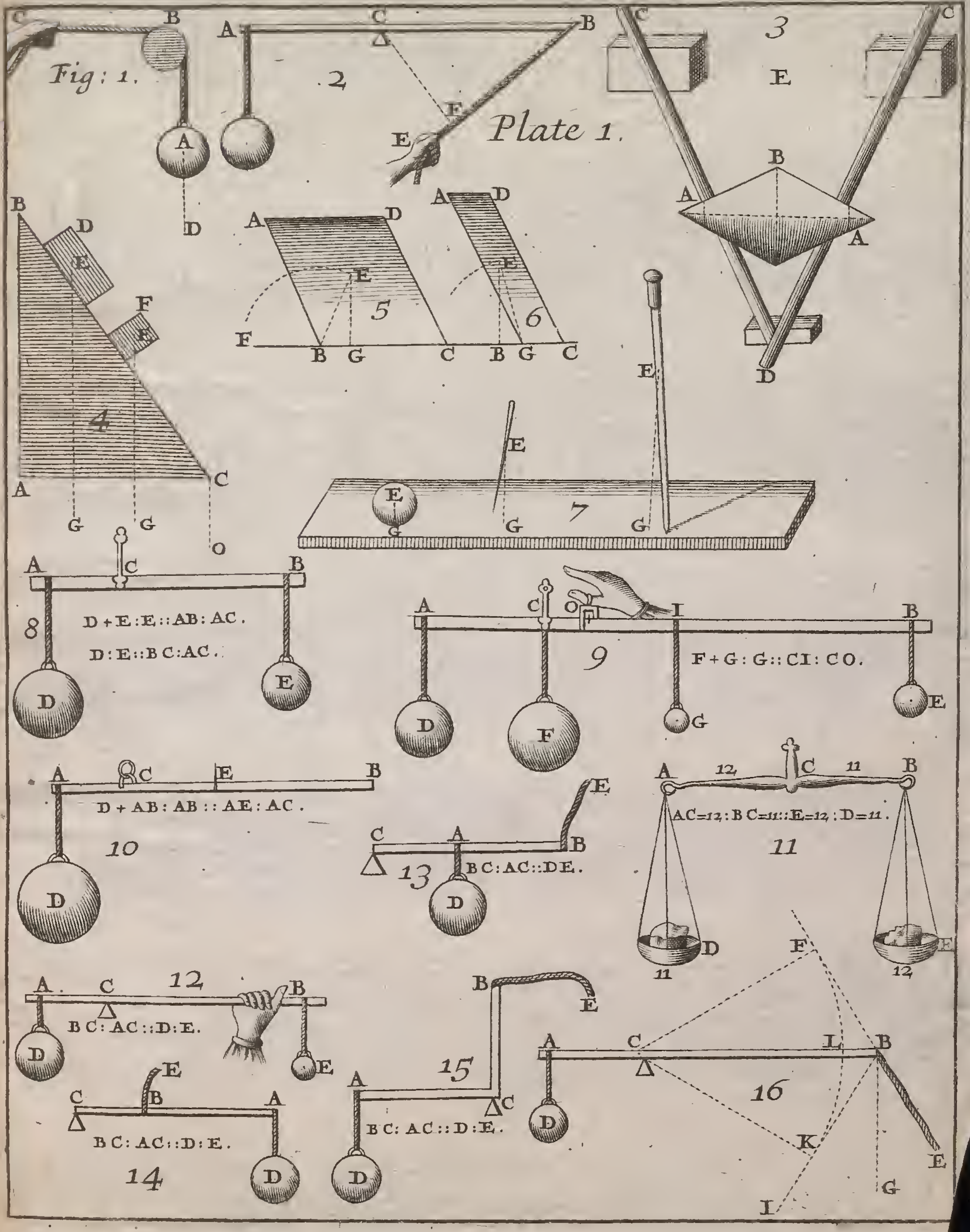
Fig: 1.
Plate 1.
D + E : E :: AB : AC.
D : E :: BC : AC.
F + G : G :: CI : CO.
D + AB : AB :: AE : AC.
AC=12 : BC=11 :: E=12 : D=11.
BC : AC :: DE.
BC : AC :: D : E.
BC : AC :: D : E.
BC : AC :: D : E.

† How y^e Rays coming fr^m every point of an Object & refracted thro' y^e sev^ll Humo^rs of y^e Eye, meet again att as many respec= tive points in y^e Retina, & there form an exact Image of y^e Object; How these points of y^e Retina, being every one y^e Extremitys of Small nerves reaching quite to y^e Brain, w^n Struck w^th any Object, transmitt y^e Image of it entire to y^e Brain, in w^ch y^e most Immediate organs of y^e Soul are probably lodg'd; How each point of y^e Optick nerve of one Eye meets w^th its correspondent point of y^e Optick nerve of y^e other Eye, & make together but one distinct Image, to work upon y^e Sense; The corporeall Image of an Object being trac'd to y^e Brain, How an Incorporeall one (i.e. y^e very perception of it) is rais'd in y^e Soul, by those cer= tain Moc̄ons in y^e Body, to w^ch She's united; W^nce proceeds y^e clearness & distinctness of y^e Image perceiv'd, W^nce y^e perception of its Situac̄on, Distance, Bigness, Figure & Number, Moc̄on or Rest, may be seen att large, as they are excellently discours'd on, in Rohault's Physicks part 1^st, chapter's 31, 32.

N. B. That all Images w^tsoever are inverted in y^e Eye, agreeable to y^e Effect of any Convex Lens; But by continuall use, when y^e upper points of y^e Retina are touch'd, y^e Sense is admonish'd to have respect to y^e lower part of y^e Object, & fr^m a Moc̄on on y^e lower p^tt of y^e Retina, to con= sider y^e upper end of y^e Object; so y^t any Object y^t ~~appears~~ is painted upright on y^e Retina must appear to y^e Sense, as it really is, Inverted.

† of an Infinite Number of Small nerves standing perpendicularly (63
on ye Convex of ye Eye, on wch ye Images of Externall Objects are
painted. The Figure of ye Eye is Sphericall, being ye only Figure
wch can turn every way in ye Hole, it fills up.

Now because those Rays only, wch come fm any single point of an Obj.
& fall on ye Middle part of ye Eye att M, are united att one point
on ye Retina (those yt fall att A B obliquely, not being exactly un-
ited wth ye Rest at ye point) therefore ye Eye is furnish'd wth an
Uvea, an Opake Coat, wch intercepts all ye ose Rays, yt fall obliquely

Plate 8, Fig. 8.

The Pupill or Hole in ys Coat has powr to dilate or contract it (on ye Eye)
self, to let more or less Light pass thro' it; & in ye Day-time 'tis but
small, for too much Light fm ye Sun wd hurt ye Eye; In ye Night
time it grows wider, to let in all ye Light it can, to affect ye Re-
tina. And This is ye Reason, why att Twylight things appear
biggr yn they are; for ye Pupill being very wide, a great many
Rays come on ye Retina, wch fall on ye Cornea very obliquely, &
ysfore will not all be united in one point of ye Retina, but takes
up some Space on it, & so ye Image of ye Hole will be much greatr
yn it ought to be. 'Tis on ye same account, yt a Candle in ye
Night seen att a Distance, appears much greater yn it rea[lly is]
& ye same is true of ye Fix'd Stars, for they appear much less,
if we look att ym thro' a small hole in a paper.

To Make all ys plain, Take 2 Tin Tubes to go one wth in ye othr, so yt
you may make ym Longer or shortr as you please; & att one
end of ye Tubes was put a Lens, & att ye othr was fasten'd a
peice of thin oil'd paper, or any thin Membrane of an Animal
to represent ye Retina; & ye othr end, where ye Lens is put, be
cover'd wth a Lid, in wch must be made a small hole, to repsent
ye Pupilla; yn if you draw ye Retina backer or forwd, you
will att a certain distance see ye Images of Externall objects, pain-
ted on it, in yeir true Colors, as in ye Dark Chambr or Magic Lanthorn.

Since yn ye Eye is a Lens, wch projects ye Images of Externall objects
on ye Retina; If ye Eye shd keep always ye same Figure, & ye Reti-
na ye same distance behind it, yre wd be but one certain & de-
terminate distance, att wch it cd see objts distinctly. (v.g.) If ye
Retina were just att ye distance of ye Focus of ∥ Rays, fm ye Cor-
nea, no objects wd have yeir Images distinctly projected on ye
Retina, but yose wch are att a good distance fm it, so long as ye
Eye kept yt Figure; But if ye Eye were of such a figure, as to
cast ye Images of near Objects on ye Retina, if ye Objects were
farthr remov'd, ye Images wd not fall on ye Retina, but betwn
ye Cornea & it. If yn ye Eye kept one & ye same Figure always,
yre wd be no Distinct Vision, but wn Objects are att one determinate
distance; wch wd be very inconvenient for Animals; & therefore,
to remedy ys, ye Eye has a powr of changing its Figure, whereby ye
Cornea

† of an Infinite Number of Small nerves standing perpendicularly
-- ye Convex of ye Eye, on wch ye Images of Externall Objects are

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Plate 8,
Fig. 8.

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Plate 2

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to remedy ys, ye Eye has a powr of changing its Figure, whereby ye

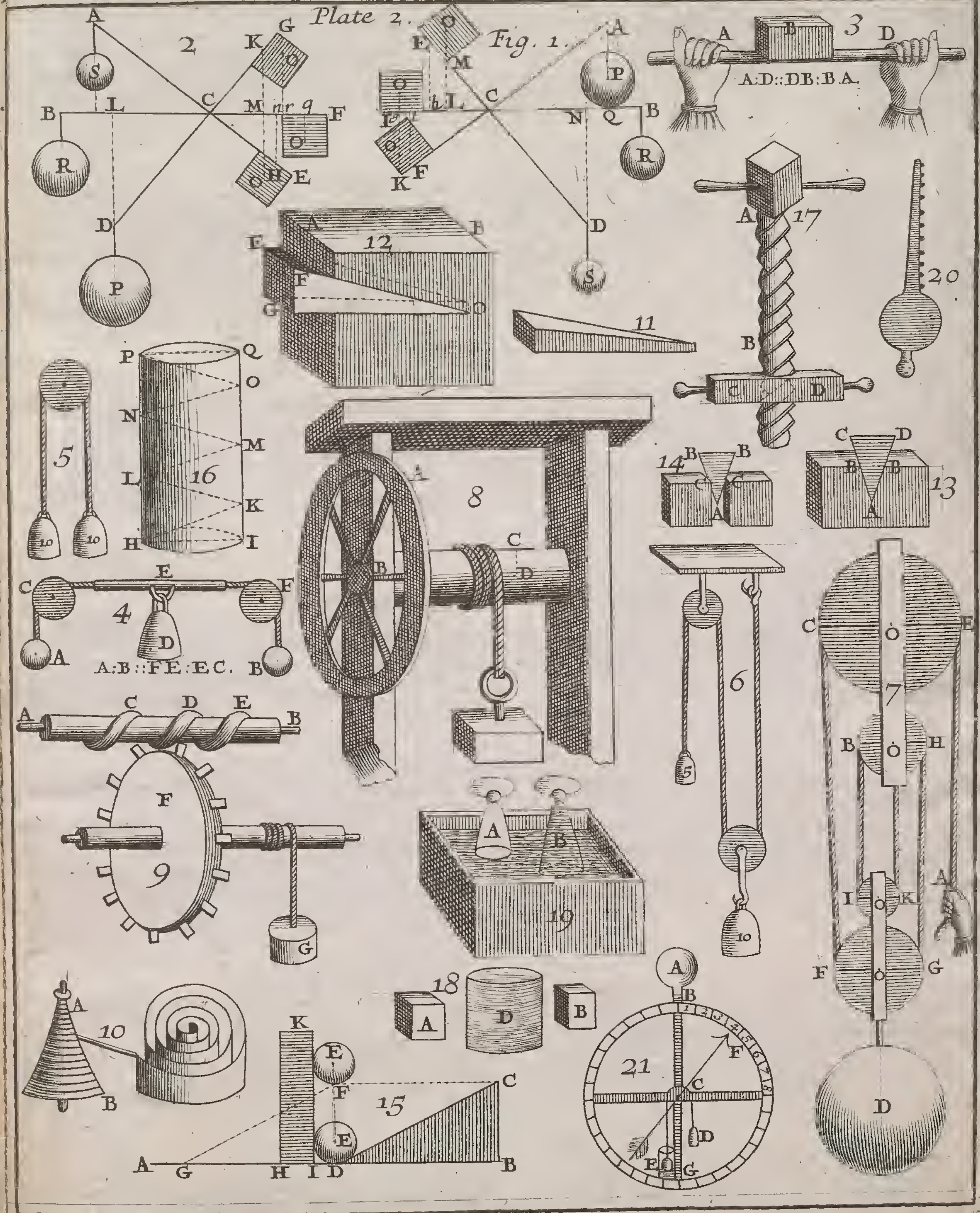

Plate 2.

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♀ This power of ye Eye to change its Figure depends on ye Muscles wch are Six, one pulling straight upwds call'd ye Elevator, a 2d straight downwds wch is ye Depressor, a 3d pulling inwd to ye nose viz. ye Adductor & 4th fm it, ye Abductor; these 4 are call'd Recti: ye 5th is call'd Obliquus Superior,× 6th Obliquus Inferior, both crossing ye other 4 obliquely, & seeming to come fm ye Corner nearest ye Ear; This being below ye Eye yt above it. Now every Muscle in a Mans Body has a certain Liquor, like ye Finest air diffus'd thro' it, wch they call ye Animal Spirits, wth wch ye Muscle being Swollen contracts, & conseq. if it be ye Elevator, lifts up ye Eye, if ye Depressor, pulls it down &c. But wn all four swell & contract yms elves together then (wt is to be remark'd here) ye Eye must necessarily somewt change its Figure & grow flattE. | Rohault. c. 28. p. 1. On ye Other hand wn ye 2 Oblique Muscles, they swell & contract, they squeeze ye Eye together, & change its Figure into a more gibbous & prominent, longer before, & conseq. deeper behind; so yt ye Chrystalline Humor [illegible] is brot farther off fm ye Retina: as in ye former change, it was brot nearer to it.

× al. Trochlearis.

Cornea is sometimes part of a Larger Sphere, sometimes of a less= (64
er; & it is on ys acct yt ye Eye was made to consist of variable & flexible humrs & parts: ye most moveable of all which is ye watry humr lying imediately under ye Cornea; next to wch is ye Chrystalline of ye firmest consistence; ye Chrystalline is closely embrac'd by ye Ligamentu Ciliare, by wch 'tis suspended, & ye Fibres of ye Ligament, by their contraction or dilatacon, bring ye Chrystalline forwd or backwd: wn ye Chrystalline is brot forwd, it forces outwds ye Aqueous Humor, & makes ye Eye more protuberant, or ye Segmt of a less Sphere: on ye Contrary, wn ye Chrystalline is brot back= wards, ye Aqueous humor returns also, & ye Eye becomes more Flat or ye Segmt of a Larger Sphere: So yt by ye Motion of ye Chrystalline, ye Cornea is made more or less Convex; ye greatest Refraction being made on ye Cornea.

Tis by ys Mobility or Changeableness of ye Eye, yt we are made to see Objects att difft distances fm us. If ye Objects are att a Distance, ye Eye, yt looks on ym, grows Flatter; if they are near us, ye Eye grows more Convex. Now if ye Eye cd apply it self att all distances to see objects fm us, we cd always see every Objt distinctly, & near Objts wd be brot so near ye Eye, yt we cd see ym magnified in any proportion, we pleas'd: For we estimate ye Magnitude of Objects seen wth our Eye, by ye Angle under wch they appear;

Plate 8, Fig. 10. Thus ye Object AB appearing under ye Angle AEB, its Image takes up ye Space ab on ye Retina; but ye Objt CD appearing only undr ye Angle CED, its takes up only ye Space cd on ye Retina.

One & Same Object att difft distances on ye Retina will appear under very different Angles; Suppose AB ye Object, & ye Eye att O, ye Angle

Fig. 11. under wch it appears, is ye angle AOB; if ye same Objt be remov'd to ab, ye Angle under wch it appears, is aOb; if it be brot to $\alpha\beta$, ye Angle att ye Eye is $\alpha O \beta$: So yt ye Angle will still be greater, ye nearer ye Object comes to ye Eye.

Suppose yn a Small Objt AB, wch att ye Ordinary distance, att wch ye Eye sees under ye Angle ACB ~~___~~ is so very Small, yt ye Eye can't perceive

Fig. 14. ye pts of ye Objt distinctly; if yn ye Eye were brot 10 or 100 times nearer (v.g.) to D, & if it cd form it self to see distinctly att all distances, it wd appear to ye Eye under ye Angle ADB 10 or 100 times biggr yn ACB, & conseq. ye Objt will appear 10 or 100 times magnified. But yn, tho' ye Eye consisting of flexible pts can change its figure, so as to see att sevl distances; yet ys mutability is wthin certain limits, & yre must be certain distances, in wch an Object must be put to be seen Distinctly. So yt if ye Objt be put nearer to ye Eye yn ys determinate distance, it can never be seen distinctly, ye Image not falling on ye Retina; but its place wd be either behind ye Retina, if ye Rays cd go so far before they were intercepted, or ye Image will be Vertical & before ye Eye, if ye Objt were nearer yn ye Focus of || Rays, & conseq. it can't be painted on ye Retina.

If yre

Colour sometimes of a bl:(64

Plate 3.

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Plate 8,
Fig. 10.

O
Fig. 11.

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Fig. 14

behind ye Retina,

or ye Image will be Vertical & before ye Eye, if ye Obj.t were nearer
yn ye Focus of || Rays, & conseq. it can't be painted on ye Retina.

If ye

Plate 3

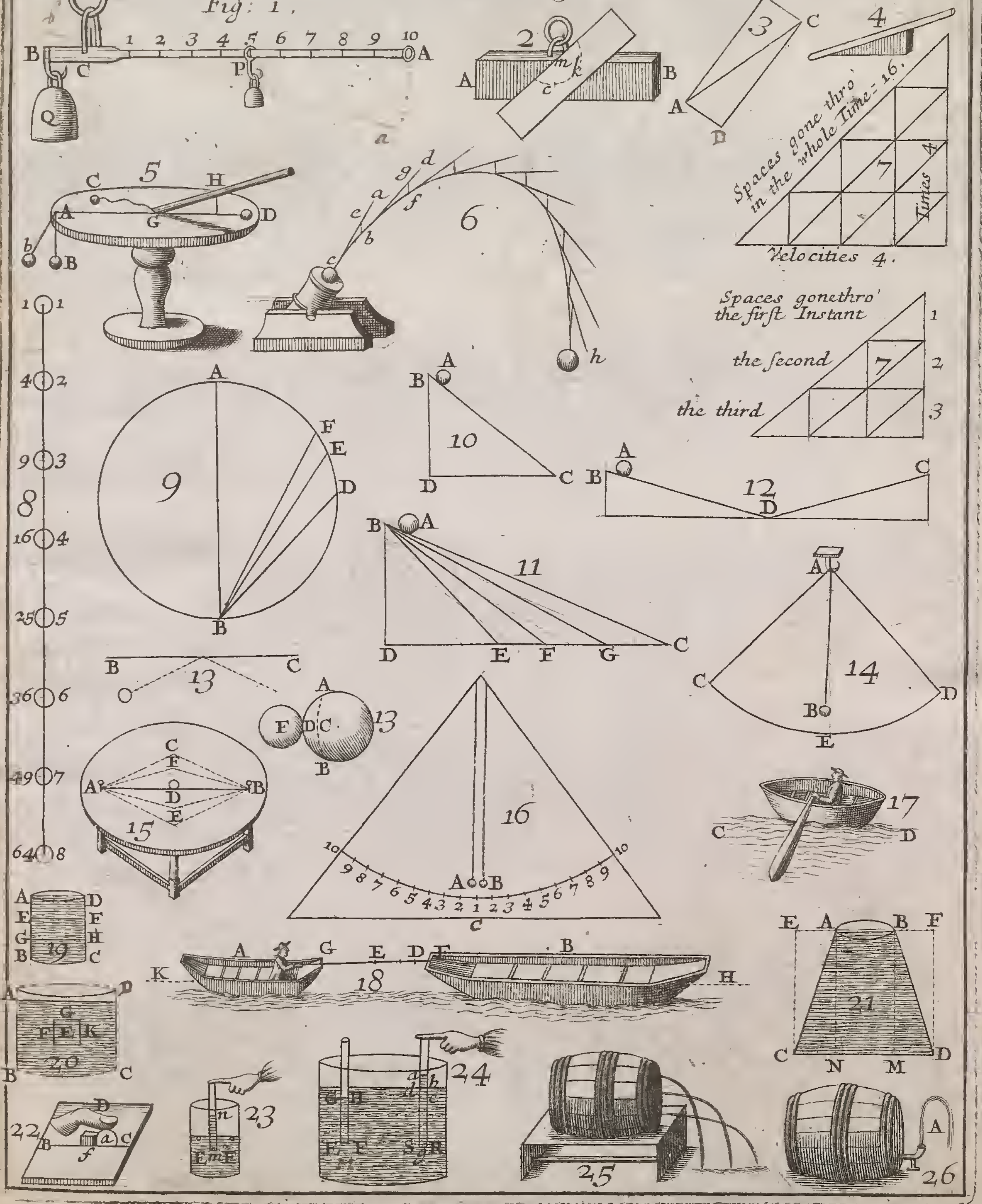
Fig: 1.
Spaces gone thro' in the whole Time=16.
Times 4
Velocities 4.
Spaces gonethro' the first Instant
the second
the third

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If yre were any solid Bodys swiming in ye Aqueous Humor, yose can never (65)
have yeir Images on ye Retina; but they will be Vertical & before ye Eye.
This is a Demonstracon yt ye Musca Volitantes can never be produc'd by Objts
swiming in ye Aqueous Humor, as Physicians generally imagin'd.

Since yn ye Object AB may be so near to ye Eye att D, as to be without ye Lim-
Plate 8, Fig. 17. its of distinct Vision; tis plain, yt it can't be seen magnified to ye
naked Eye in any giv'n position; wch it wd be, cou'd it see distinct-
ly att all distances. But if before ye Eye I put a Lens CE (wch consists
of segments of small Spheres) & ye Distance of ye Objt fm ye Lens be
less an at ot ye Focus of || Rays, ye Lens will form ye Image of ye
Object AB att $\alpha\beta$, i.e. all ye Rays wch come fm ye points A & B will
enter ye Eye, as if they had all come fm $\alpha\beta$, & ye Eye will see ye Objt
AB att $\alpha\beta$ att ye Distance necessary for distinct Vision; & it will
appear under ye Angle ADB or $\alpha D\beta$, wch is ye same it wd have
seen to ye Naked Eye, att D. If ye Objt were plac'd att ye Focus
of || Rays, yn all ye Rays wch come fm ye point A, after Refraction
thro' ye Lens, will go ||, & enter ye Eye, as if yey had come fm an in-
finite distance, so ye Eye wd see ye point A in ye line Aα produc'd
in Infinitum. The same thing is true of ye point B, & ye Object
wd be seen att an infinite distance under ye Angle $\alpha D\beta$, wch
is ye very same, under wch it wd be seen by ye Naked Eye, if it
cou'd see it att D distinctly.

Suppose an Object AB, wch to ye Eye att C (ye ordinary distance for dis-
tinct Vision) appears under ye small angles ACB; If yn I wd see
Fig. 16. ye Object an 100 times magnified, I take a small Lens, whose
Focus Distance for || Rays is an 100 times less yn AC or BC, & put
ye Lens att D, so yt ye distance of ye Lens fm ye Object may be an
100 times Less, yn ye distance of ye Eye att C fm ye Object; if yn I
bring my Eye to D to ye Lens, I shall see ye Object thus magnified
distinctly, because it lyes att a greater distance fm Eye; for most
mens Eyes are so fram'd, as to see Objects att a good distance fm
ye Eye distinctly.

If yre were an Object AB, & a Lens E, whose Focal distance is FE, ye
Object wd appear by ye Lens, under ye Angle AEB; if yre were a
Fig. 15. Lens, whose Focal distance is DF, ye angle under wch ye Objt
will appear will be ADB, greater yn AEB; if yre was another
Lens att C, wse Focal distance is CF, ye Angle, under wch ye Objt
wd appear thro' ye Lens is ACB, wch is still greater yn AEB.
The Less then ye Focal distance of || Rays of any Lens is, ye more
'twill magnify ye Objt; & if ye Lens be equally convex on both
Surfaces, ye Focal distance for || Rays is a semidiameter's distance
fm ye Lens: ye Less yn ye semidiameter of ye Sphere is, of wch
Segment ye Lens is made, ye more it will magnify ye Object. &
ye whole art of Magnifying Objts by single Microscopes, is to
grind Glasses of portions of very small Spheres.

Leewen-

If ye were any solid Bodys swiming in ye Aqueous Humor, yse can never (65
have their Images on ye Retina, but they will be visible & before ye Eye

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Plate 8; Fig. 17.

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Fig. 16

Fig. 15

ye whole art of magnifying Objs by single Microscopes, is to grind Glasses of portions of very small Spheres.

Lewen-

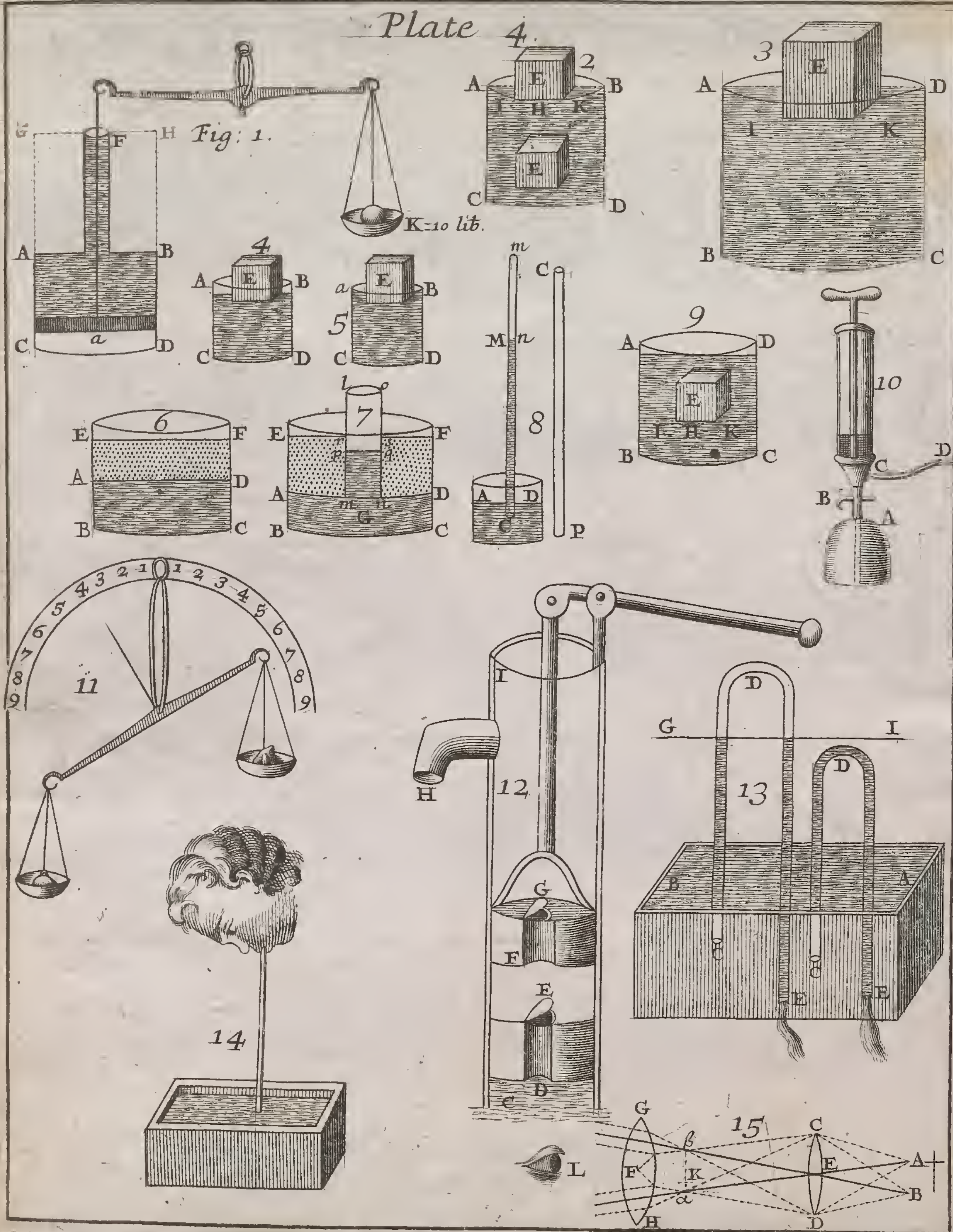
Plate 4.
Fig: 1.
K=10 lib.

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The Eye, wch of it self can hardly see distinctly wthin ye distance of a foot, by ye help of this Microscope clearly discern's a Flea or Smaller animal, att ye distance but of one Inch; wnce it appears, yt ye Diameter of ye Image repsented in ye Glass, is to ye Diameter of it att a foot's distance, as 12 to 1, & conseq. ye Superficies to ye Superficies, as 144 to 1; in wch proportion therefore ye Object is magnified to ye Eye.

Roh. part. 1. c. 33. art. 15.

Lewen-hoeck & Melon pretend to grind Glasses, wch Focal distance (66
not much exceeds $\frac{1}{100}$ of an Inch; I've heard of some yt are less, & if they were less, fall on pap^r, yre wd be need of anoth^r Microscope to find 'em wth.

To know how much any of ye Single Microscopes Magnify, Take a small peice of paper, suppose $\frac{1}{4}$ of an Inch diamet^r, & past it on ye Wall, & take ye Microscope & put any small Objt att ye Focus of || Rays fm it, yn recede so far fm ye Wall, 'till ye paper on it appears of ye same bigness wth ye Objt seen thro' ye Microscope: yn Consider wt proportion ye Distance of yr Eye fm ye Pap^r bears, to ye distance of ye Objt fm ye Microscope; & in ys proportion ye Objt will be magnified, or appear greater, yn it wd do, were it plac'd at a semidiamet^r distance fm ye Eye, wth ye paper on ye Wall.

We may Perform ys more Easily Thus: Take a Round peice of pap^r of abt 2 or 3 inches Diamet^r, & Dye it Black wth Ink, yn past it on a pane of Glass in ye Window, & recede so far fm it, 'till, looking thro' ye Microscope wth one Eye on ye Objt, & ye oth^r on ye pap^r, you perceive 'em both to be of one bigness, or ye one exactly to cover ye oth^r; The proportion betwn ye paper & ye Objt will be exactly ~~as ye distance~~ as ye distance of ye Objt fm ye Microscope, to yt of ye Eye fm ye Paper; & Conseq. wn it appears of ye same Bigness wth ye pap^r, is Magnified in yt proportion.

Tho' Most Mens Eyes have such a Flexibility or Changeableness of Figure yt they cannot only see Objts att a great distance, if they appear under any Sensible Angle, but also Those yt were within 3, 2, or 1 Foot of yir Eye; yet yre are Sev^ll, wse limits of distance for distinct objts as to yeir Vision, are much less; (v. g.) Some can't see Objts, but wn they are very near ym, or close to yeir Eye, wch being very Convex, or ye Segmt of a small Sphere, will unite ye Rays of Objts att a distance before they come to ye Retina. Such persons are call'd Myopes.

On ye Contrary, yre are Those, wse Eyes are very Flat, or ye Segmts of larg^r Spheres, who can't see, unless ye Objt be at a good distance fm ym, & ye Rays, wch come fm one point & fall on yeir Eye, be quam proxime Parallel.

Because Old Men have generally yeir Eyes Flat, so yt they can't see but at a distance, yrefore Those who have ys Fault, are call'd Presbytæ.

Both yse sorts of Vision may be help'd by Lens's; for Those, who are Short-sighted & can't see any Objt, but such as are very near ym, by looking thro' a Concave Lens, will see distinctly Objts, wch at ye same distance without ye Lens, they cd not see, but very Confusedly.

Suppose an Object A B C, & ye Eye of a Myops att E, ye Objt being without ye limits of distinct Vision, will be seen Confus'dly by ye Eye att E, but if you put a Concave Lens att G betwn ye Objt & ye Eye, all ye Rays wch come fm A B or C, will enter ye Eye, as if they had come fm a b c, wch are much nearer to ye Eye & within ye Limits of Distinct Vision. Fm wch Experimt it is plain, yt, by ye help of such a Lens ye Eye of a Myops will see distinctly ye Object A B C, tho much less yn if it had seen it without ye Lens.

Plate 8, Fig. 9.

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Lewen-hoeck & Melon pretend to grind Glasses w^{ch} Focal distances (66

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Plate 5

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Plate 8, Fig. 9.

Vision. From w^{ch} Experim^{t} it is plain, y^{t}, ...
y^{e} Eye of a Myops will see distinctly y^{e} Object ABC, tho' much less
y^{n} if it had seen it w^{th}out y^{e} Lens.

As

Plate 5

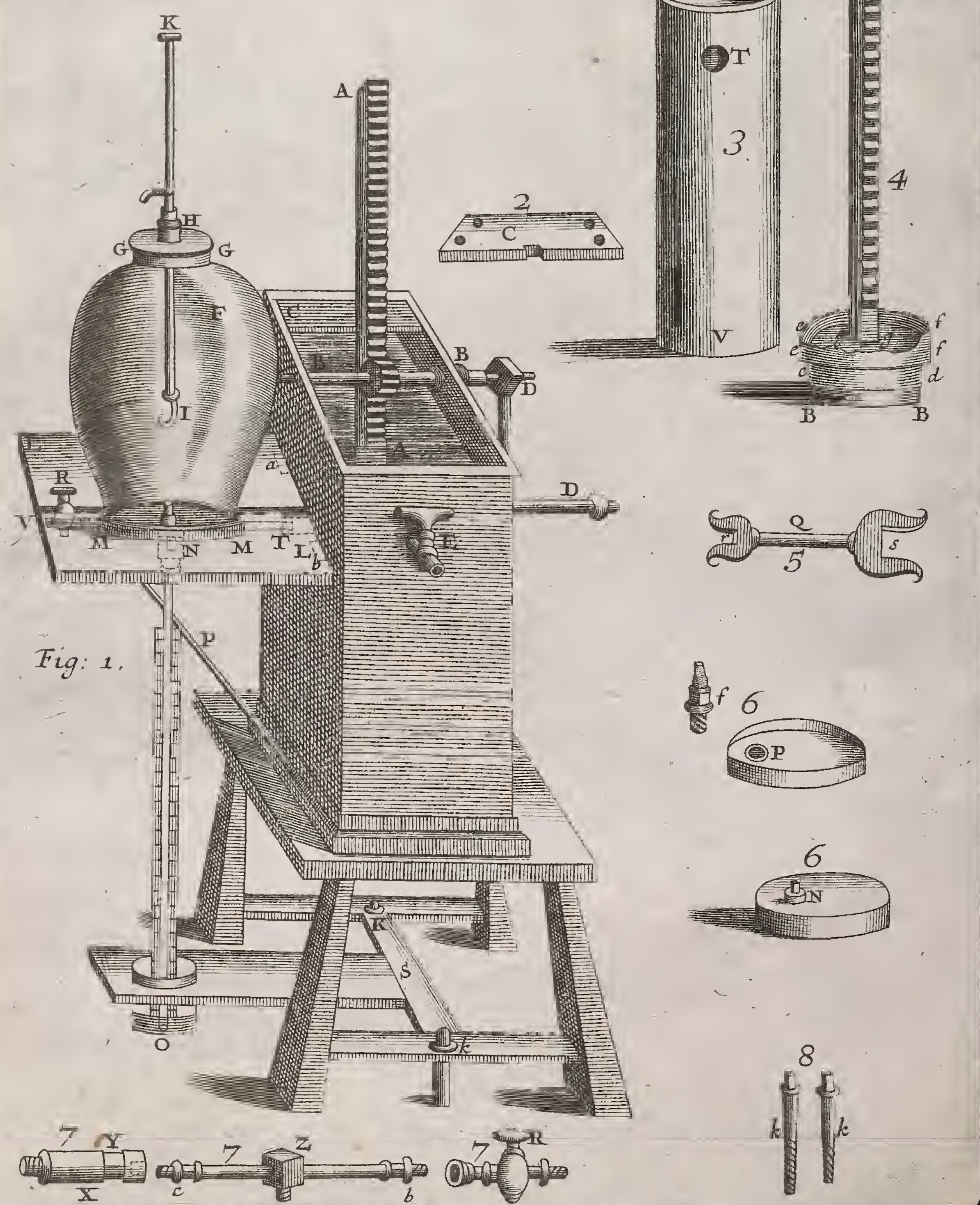

Fig: 1.
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D
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b
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S
k
O
2
C
3
T
V
4
A
e
f
e
f
c
d
B
B
5
Q
r
s
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f
P
6
N
7
Y
X
7
Z
c
a
b
7
R
8
k
k

As a Concave Lens makes Short-sighted people see more distinctly so also a Convex Lens helps ye Sight of ye Presbytæ. For suppose AB an Object & ye Eye at C; this Objt is so near ye Eye yt it can't be seen distinctly by it: If yrefore yre be a Convex Lens put at E, so yt ye Object may be wthin ye Focus of ∥ Rays, ye Eye will see ye Objt AB at αβ, at a farther distance & within ye Limits of Distinct Vision; &, because ye space αβ is greater yn AB it will see it Magnified, whereas an Objt seen thro' a Lens fitt for a Myops, always appears Less. (67)

Plate 8.
Fig. 12.

Double Microscopes are those wch consist of 2, 3, or 4 Lens's, yt are design'd to Magnify ye Object.

The First Sort is made after ys Manner. C is a Lens of a Small Sphere, before wch ye Object AB is plac'd att such a distance, yt ye Image made att ye Lens C may be cast out att a great distance on ye other side, viz. att ab, so yt if ab be 10 or 100 times farther fm C, yn AB is, it will be 10 or 100 times greater yn AB. DE is another Lens, wch is large & put so near ye Image ab, yt ab will either be in its Focus of ∥ Rays, or somewt nearer, so yt ye Image of ye Image ab made by ye Lens DE, may be cast out at a distance fit for distinct Vision: Now if ye Eye be apply'd at G, it will see ye Object under an Angle, equall to EFD, & conseq. magnified & att a distance fitt for distinct Vision.

Plate 9.
Fig. 1.

Most of ye Double Microscopes now in use have 3 Glasses & are made Thus: C is ye Object Glass wch is ye portion of a small Sphere; AB is ye Object somewt farther yn ye Focus of ∥ Rays, so yt ye Image may be cast out & fill ye Space ab 10 or 100 times greater yn AB. DE is another Lens or Segmt of a large Sphere plac'd att a little distance fm ab. To ys Joyn ye 3d Glass GH, wch is ye Segmt of a Sphere somewt less yn DE; so yt ye distance betwn ye 2 Glasses GH & DE may be less yn ye Distance of ye Focus of ∥ Rays of ye Glass GH; & yt ye Rays wch come fm ye Image ab, may pass ye 2 Glasses GH & DE, & after Refraction enter ye Eye at L, so yt all those Rays wch come fm ye same point of ye Image ab, may enter ye Eye as if they had come fm an infinite distance. i.e. The 2 Glasses GH & DE ought to be so plac'd yt ye Rays, wch come fm any one point of ye Object ab, may after Refraction thro' ye 2 Glasses run Parall, & so form in ye Eye a distinct Image. For tis plain, yt in ys Case, ye Eye will see ye Object much magnified & distinct.

Fig. 2

By ys Microscope, ye Eye can perceive a greater portion of ye Object, yn by ye former; because ye Rays at b & a wd fall so Obliquely on ye Glass DE, yt without ye 3d Glass GH, they cd not enter ye Eye, & conseq. wthout this Glass, ye Eye wd only see ye middle part of ye Object.

As Microscopes are us'd to discover ye small pts of ye Bodies, we have near us, & wch we can put att a due Distance fm ye Microscope;

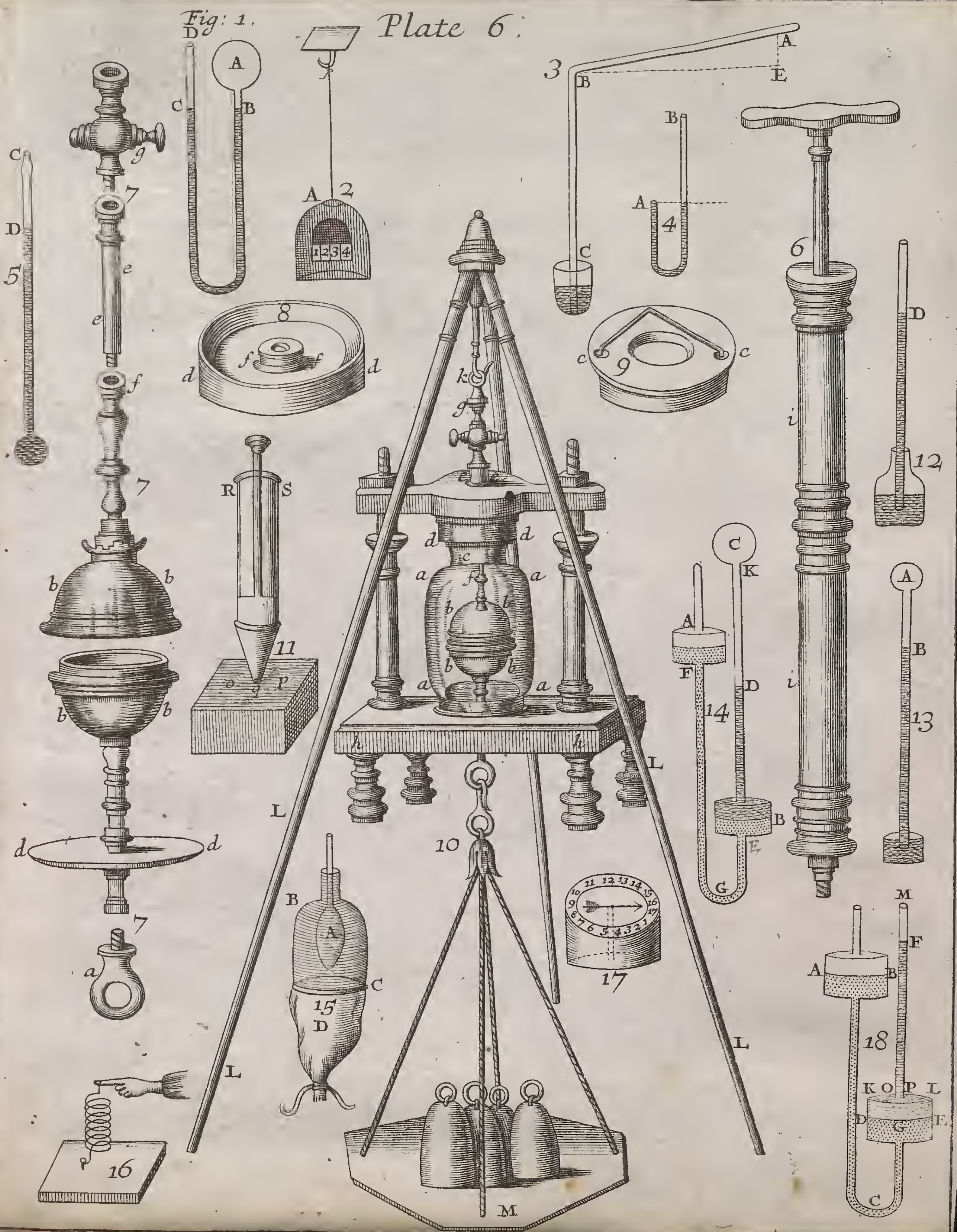
So Telescopes are fitt for discerning Bodies distinctly, yt are att a grt distance fm us; so yt ye Rays, wch come fm any point of ye Object & fall on ye Obj-glass of ye Telescope, may be conceiv'd as ∥, & conseq. they'll unite & form ye Image att ye Focus of ∥ Rays.

The

As a Concave ...
Plate 8. Fig. 12. a Convex ...
& ye Eye ...
it: If ye ...
ye Focus ...
& within ...
AB, it wo...
for a Mi...
Double Micros...
to Magni...
The First Sort is ...
Plate 9. Fig. 1. ye Object ...
C may be ...
ab be s...
greater ...
ab, yt a...
ye Image ...
Distance ...
see ye Ob...
a distanc...
Most of ye Dou...
Fig. 2. C is ye Ob...
somew ...
& fill ye ...
or from ...
ye 3d Gl...
Distance b...
of || Rays ...
pass ye 2...
all ye Ra...
as if they ...
ought to ...
ab, may ...
a distinct ...
much ma...
By ys Microsc...
former; be...
without ye ...
ye Eye wo...
As Microscopes ...
we can put ...
So Telescopes ar...
us; so yt ...
of ye Tele...
are att ye ...

Plate 6

Plate 6.



I. The First & most Simple Sort of Telescope, is ye Astronomick for looking att ye Stars. CD repsents ye Object Glass, wch is a Portion of a very large Sphere; AE & BE are 2 Rays, wch come fm ye Extremity of an Object placed att a great distance, as ye Objt AB is to be Supposed; All ye Rays wch come fm ye same point of ye Objt yt AE came fm, will after Refraction thro' ye Lens meet att α, & all ye Rays wch come fm ye same point yt BE came fm, will aftr Refraction meet att β; So yt ye Image of ye Object will be $\alpha\beta$, att ye Distance of ye Focus of ‖ Rays (as you may see by ye pricked Lines.) Suppose GHF a Lens of a much greater Convexity, or a Segmt of a much less Sphere, plac'd so near ye Image $\alpha\beta$, yt $\alpha\beta$ may be in its Focus of ‖ Rays. i.e. all ye Rays wch come fm ye points α & β may after Refraction run Parall & enter ye Eye att L, as if they had come fm a great distance: These Lens's being thus adapted & put in a Tube, ye Eye will see distant Objects distinctly, & magnified in ye proportion, yt ye Focal distance of ye Glass CD is greater yn ye Focal distance GH: 68

Plate 4, Fig. 15.

1st The Eye will see ye Object distinctly, because ye Rays wch come fm ye points $\alpha\beta$ falling on ye Eye att L, as if they had come fm a great distance, will be Exactly united in ye Retina, & yre form a Distinct Image.

2dly The Object will be seen much greater, yn without ye Telescope; for ye Angle under wch ye Object is seen without ye Telescope, is ye Angle ALB, & ye Image on ye Retina of ye Eye is $\alpha\beta$: but ye Angle, under wch ye Image is seen wth ye Telescope, is ye Angle GLH, & ye Image made on ye Retina is IK, & Therefore, as much as ye Latter angle & Image are greater yn ye former, So much is ye Objt magnified by ye Telescope.

Plate 9, Fig. 3.

Again, let AB be 2 Rays coming fm ye End of an Object at an infinite distance, whose Image is $\alpha\beta$, ye Bigness of wch is determin'd by ye Angle $\alpha E\beta$ wch those 2 Rays make in passing thro' ye Object Glass without any Refraction, because they are ye Axis of 2 pencils of Rays. Let ye Focal distance of ye Objt Glass be EK, & yt of ye Eye Glass be FK, & AEB ye Angle under wch ye Object is seen without ye Telescope; Now because ye Image & ye Objt appear under ye same Angle fm ye Lens, ye Angles AEB & $\alpha E\beta$ will be Equall, & Conseq. yt of ye Image equall to ye Angle under wch ye Objt appears seen without ye Telescope; But ye Eye at L sees ye Image $\alpha\beta$, undr an Angle equal to $\alpha F\beta$, & conseq. as much greatr as ye Angle $\alpha F\beta$ is yn $\alpha E\beta$, so much greatr will ye Objt appear wn seen wth ye Telescope, yn wn seen without it; But so much as EK is greater yn FK, so much is ye Angle $\alpha F\beta$ greater yn $\alpha E\beta$, i.e. ye Objt is Magnified in proportion to ye Focal distance of ye Object Glass, keeping ye same Eye-Glass, & conseq. ye longr ye Focal distance, i.e. ye largr ye Sphere is, of wch ye Lens is a portion, ye more ye Objt will be magnified. And therefore ye Whole perfection of yse sort of Telescopes, is to gett Objt glasses well ground of a long Focal Distance. There be some of

Plate 4, Fig. 15.

yse

I. The First & most Simple sort of Telescope, is ye Astronomick for (68

Plate . looking att ye Stars. CD represents ye Object Glass wch is a Portion of

Fig. 15

Plate 7

1s

2d

Plate

Fig. 3

3

Plate 4

Fig. 15

glasses well ground of a long Focal Distance. There be some of

ye

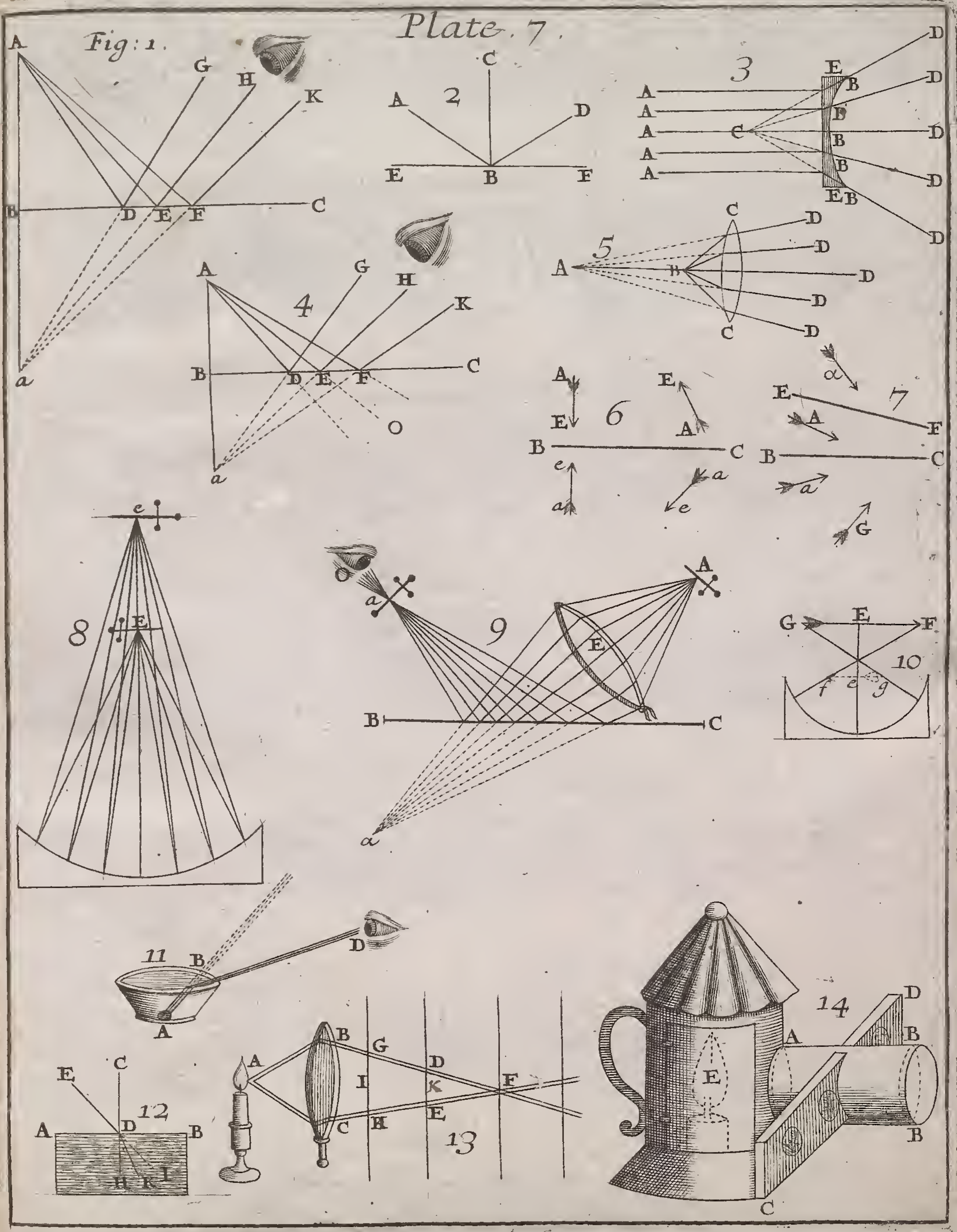


Plate. 7.
Fig: 1.
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9

these Telescopes 150 or 200 foot in Length; but tis very difficult to Manage & turn ym, as one pleases. Tis plain yt ye Objt $\alpha\beta$ is inverted, in respect of ye principal Object, & conseq. wtever Objts we look att with yese Telescopes, will appear inverted.

II. Galilaeo's Telescope does likewise consist of 2 Glasses, whereof ye Objt Glass is Convex, & a Segmt of a lesser Sphere; they are fix'd in a Tube after ys Manner:

Plate 9, Fig. 4. CD is ye Objt Glass, wse Focus of ∥ Rays is att $\alpha\beta$, i.e. the Images of all distant Objts made by ye Glass CD, are att $\alpha\beta$; so yt K is ye Focus of ∥ Rays to ye Axis of ye Glass so yt if it were not for ye Interposition of ye Eye Glass GH, all ye Rays ∥ to ye Axis wd Converge to ye point K: but yn by ye Interposition of ye Concave Eye-Glass GH, wch is plac'd at such a Distance fm ye Image $\alpha\beta$, yt ye point K is in its Focus of ∥ Rays or Virtuall Focus: all ye Rays, wch before they pass'd thro' ye Glass GH were Converging to ye point K, will after Refraction on ye Glass GH, run ∥ to ye Axis; ye same way, all ye Rays, wch before Refraction on ye Glass GH, were Converging to ye points $\alpha\beta$, will after Refraction, run ∥ one to another, So yt ye Eye, near F, will receive all ye Rays wch were tending to ab, as if they had come fm $\alpha\beta$ plac'd att a great distance; and ye Eye will see ye Object plac'd under ye Angle $\alpha F\beta$, which is equal to aFb. And it is to be Observ'd, yt ye Image $\alpha\beta$ is inverted in respt of ye principal Object; but, because $\alpha\beta$ is inverted in respt of ab, $\alpha\beta$ will be Erected, & seen ye same way (as ye principal Objt AB is seen.

N.B. The Virtual Focus of a Concave Glass is yt point, fm wch ye Rays ∥ to ye Axis diverge after Refraction thro ye Glass; As ye point C is ye

Plate 7, Fig. 3. Virtuall Focus of ∥ Rays of ye Glass EE, because ye Rays ABD, wch before they Entred ye Glass were ∥ to yeir Axis ACB, are by Refraction thro' ye sd Glass, made to Diverge fm ye point C, as if they had really come fm yt point.

III. Because ye 1st Sort of Telescope shows all Objts inverted, & ye 2d discovers but a small part of an Objt att once; Therefore a 3d Has been

Plate 9, Fig. 5. contriv'd Consisting of 4 Glasses, viz. one large Objt Glass & 3 Eye-Glasses plac'd after ys manner. CD is ye Objt Glass, wse Focus of ∥ Rays is att ab; Or, wch is ye same thing, Let ab be ye Image of some distant Objt, yrefore it will be Inverted in respt of ye Objt. EF is an Eye Glass, a Segmt of a lesser Sphere, plac'd so near ye Image ab, yt Rays wch come fm any one point of it after Refraction thro' EF, may run ∥, & so fall on a 3d Glass GH; yse Rays falling on ye Glass GH, will after Refraction converge to yeir Focus of ∥ Rays, & form an Image $\alpha\beta$ inverted in respt of ab, & conseq. Erected in respt of ye principall Radiant AB. IK is anothr Glass plac'd so near ye Image $\alpha\beta$, yt ye Rays coming fm any point of yt Image, may enter ye Eye att L, as if they had come fm a point att a great distance, i.e. they will, after Refraction att IK, run parall,

those Telescopes 150 or 200 foot in Length; but tis very difficult
to Manage & turn y^m, as one pleases; Tis plain y^t y^e Obj^t αβ is inverted;

Plate 8

II. G

Plate

Fig. 4

N.

Plate 7

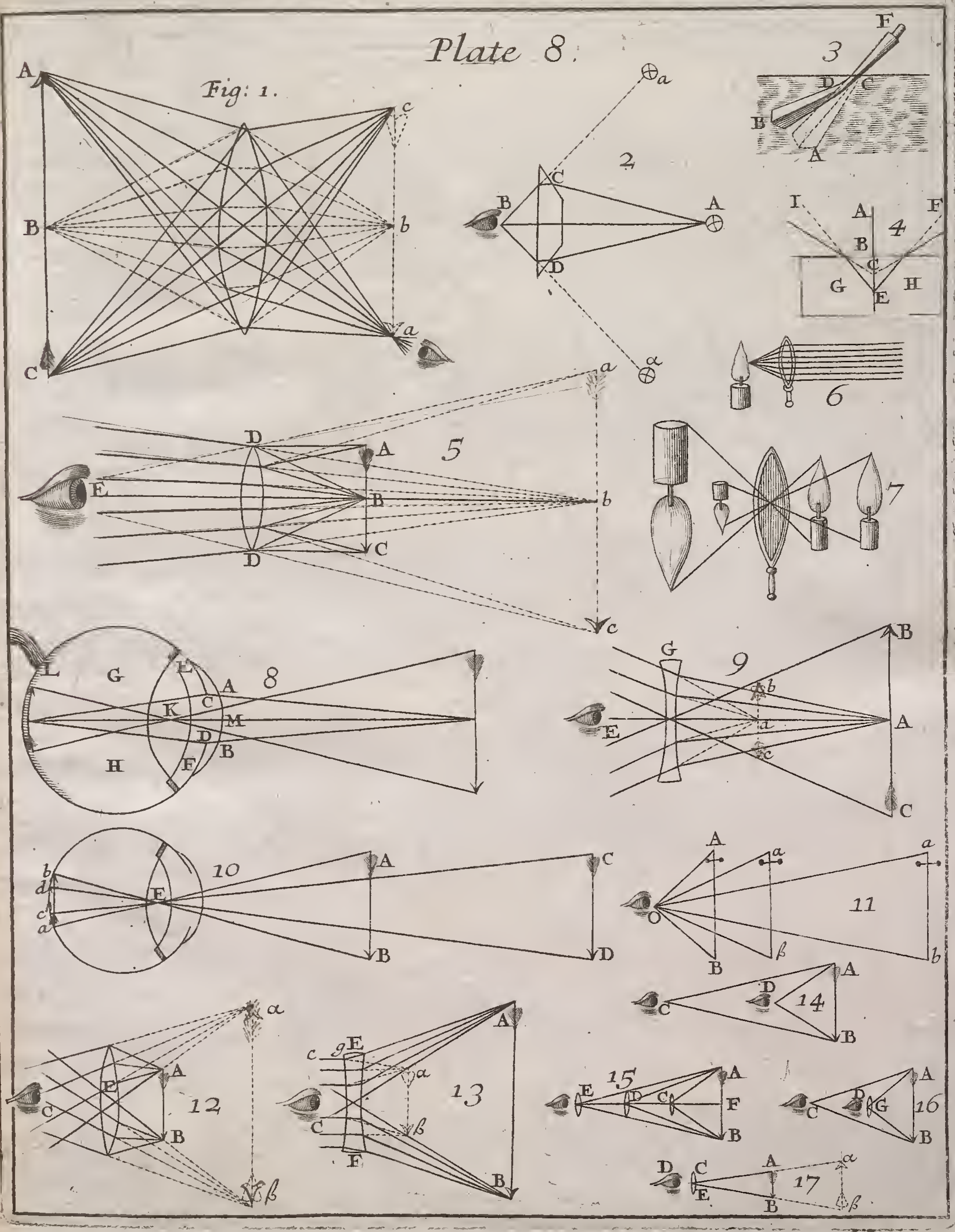
Fig. 3

III. B

Plate

Fig. 5

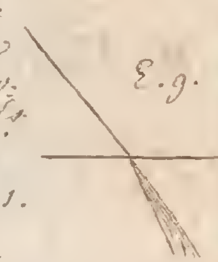
Plate 8.



x

☆ Sr Isaac Newton has made 2 observations concerning ye Refraction of Light, wch were before unknown.

I. That Rays of Light, tho' falling on ye same Superficies after ye same manner, are not Refracted after ye same manner all, but each split, as it were, into severall small Rays, of wch some are more Refracted yn others. Hence it is, yt He so accurately explains ye Nature of Light & Colours, as also yeir properties, sett down p. 70, 71.



E.g.

II. That Refraction is not made just in ye very Superficies (as was generally thought) but by degrees, by a continu'd inflexion of ye Rays, wch begin to bend in ye air a little before they touch ye Glass. From whence follow these 2 propositions, or perhaps seeming Paradoxes, 1. That not only yose Rays wch enter ye Glass, but ev'n those yt pass only thro' ye air near ye sides of it, are Refracted. 2. That those Rays also, yt come near to ye Edges of opake Bodies, such as Gold or Silver money, ye Edge of a Knife, &c are in like manner Refracted. S. Clarke's notes on Rohault part 1. c. 27. art. 37.

x Which shews yt ye uniting of those diff.t Rays together does not destroy one anothers Colour, but only restore ym to, wt they were, before they were separated, one White Ray. Thus a Mixture of Red, Orange-Color, Yellow, Green, Blue & purple dust, of equall quantity each, come very near to, & would make, a perfect White did they not by yeir hollowness necessarily absorb some Rays.

Plate 9, } & yⁿ yᵉ Eye att I, will see yᵉ Obj.ᵗ distinctly Erected, & Mag-(70.
Fig. 5. } nified. Observe yᵗ ab is yᵉ comon Focus of ∥ Rays to yᵉ 2 Glasses CD & EF; & also yᵉ Focus of ∥ Rays, to yᵉ 2 Glasses GH & IK.

Sʳ Isaac Newton's Colours.

Prop. Lights, wᶜʰ differ in Colour, differ also in degrees of Refrangibility.

Experiment. If you apply any Flat Side of a Prism to a Hole of a dark Room, to receive yᵉ Rays wᶜʰ come fᵐ yᵉ Sun; yᵉ Rays, wᶜʰ are different in Colour, will be Separated by a different Refraction,
Plate 10. } & diverge fᵐ one anothᵉʳ, as in Fig. 1, & appear distinctly of an Oblong Figure on yᵉ opposite Wall: They'll be Refracted in yˢ Order: the Red Rays will be Refracted least; yᵉ Orange somewᵗ more; yᵉ Yellow more yⁿ yᵗ; yᵉ Green yet more; yᵉ Blue more yⁿ yᵉ Green; & yᵉ Purple most of all.

Now to show yᵗ yˢᵉ Colo.ʳˢ were not made by Refraction, but were Originally in yᵉ Rays of yᵉ Sun; if you Refract any one of yᵐ never
Fig. 1. } so much wᵗʰ a Prism, (v.g.) yᵉ Purple in yᵉ Figure, it will still retain yᵉ same Colour.

If you Contract yˢᵉ Refracted Rays wᵗʰ a Burning-Glass, they'll all converge to yᵉ Focus of ∥ Rays, as in yᵉ 2ᵈ Figure; where if you receive yᵐ on yᵉ Paper, they will appear White. Now to show furthᵉʳ,
x yᵗ White is a Composition of all yᵉ Colo.ʳˢ; If you intercept yᵉ
Fig. 3. } Blue Ray wᵗʰ a peice of paper betwⁿ yᵉ Focus & yᵉ Glass, yᵉ White att yᵉ Focus will appear Reddish; If yᵉ Red be intercepted, it will appear Bluish; so yᵗ if one of yˢᵉ Colo.ʳˢ be wanting, yᵉ White is Imperfect.

If you receive all yᵉ Rays on a peice of paper betwⁿ yᵉ Focus of ∥ Rays & yᵉ Glass, they will appear in their proper Colours & Right order, & converging towᵈˢ one anothᵉʳ; but if yᵉʸ be recᵈ beyond yᵉ Focus they
Fig. 2. } will appear wᵗʰ their proper Colo.ʳˢ on yᵉ Papᵉʳ, & to have diverg'd fᵐ one anothᵉʳ & their order will be Inverted, viz. yᵉ Purple Ray will be in yᵉ place of yᵉ Red, & yᵉ Red of yᵉ Purple, &c.

To Show yᵗ yᵉ Rays wᶜʰ differ in Colo.ʳ, tho' they have yᵉ same Incidence are differently Refracted; Place a Tall peice of wood wᵗʰ an Hole in it,
Fig. 4. } & a prism behind yˢ Hole, att a Convenient distance fᵐ yᵉ Window, yⁿ wᵗʰ a Prism refract yᵉ Sev.ˡˡ Rays, one over anothᵉʳ, fᵐ yᵉ Hole in yᵉ dark Room, to yᵉ Hole in yᵉ peice of Wood, & each of yᵉ Rays will be differently Refracted on yᵉ opposite Wall. viz, yᵉ Red wᶜʰ will be Least & uppermost, yᵉ Orange next underneath, yᵉ Yellow next, yᵉ Green next, yᵉ Blue next, & yᵉ Purple most of all.

Plate 9, } & yn ye Eye att L will see ye Objt distinctly Erected & Mag- (70.
Fig. 5. } nified. Observe yt ab is ye comon Focus of ‖ Rays to ye 2 Glasses

Prop
E

Plate

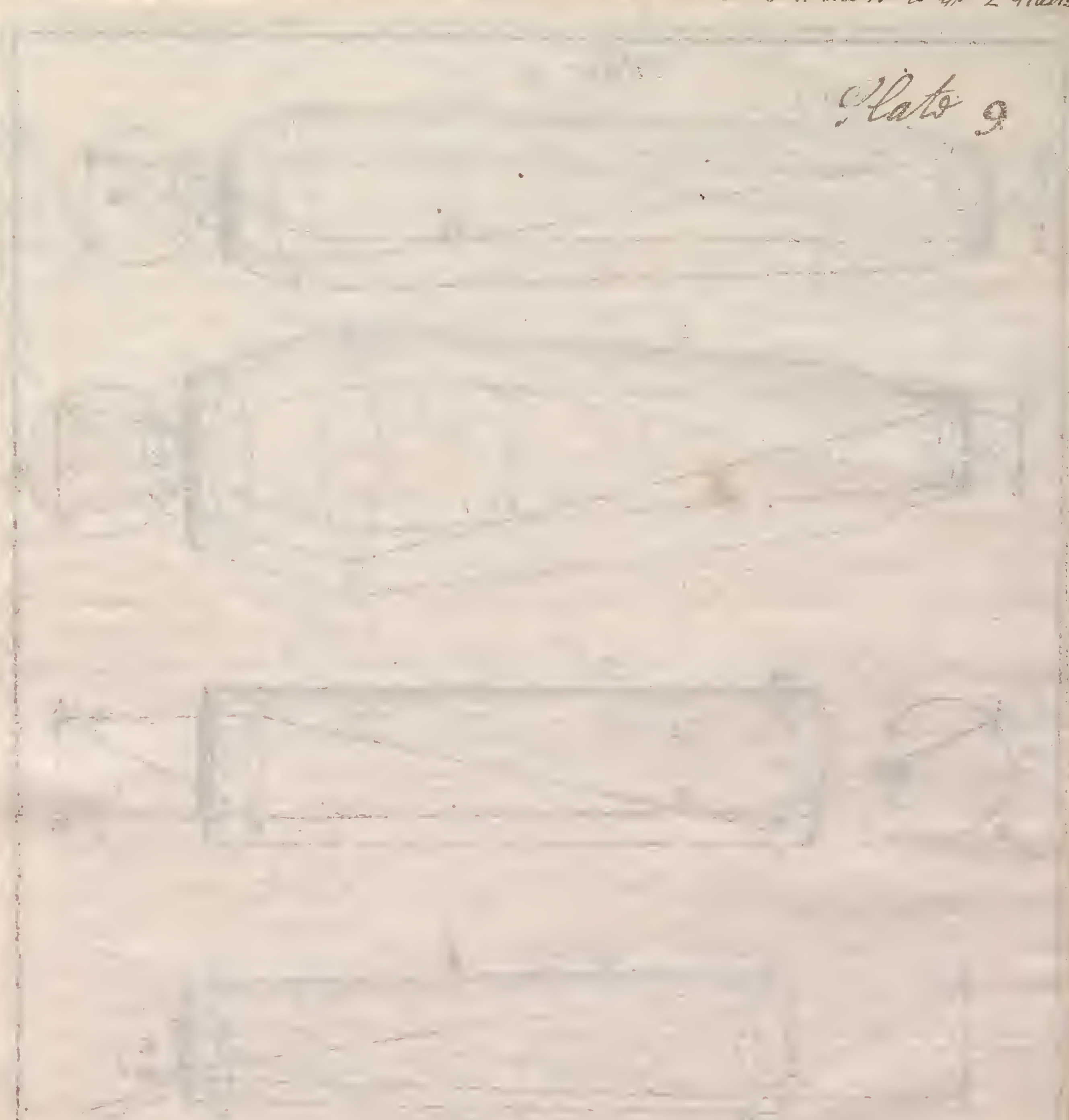


Plate 9

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Fig.
F
Fig.
If y
Fig.2
To
Fig. 4

Plate 9.

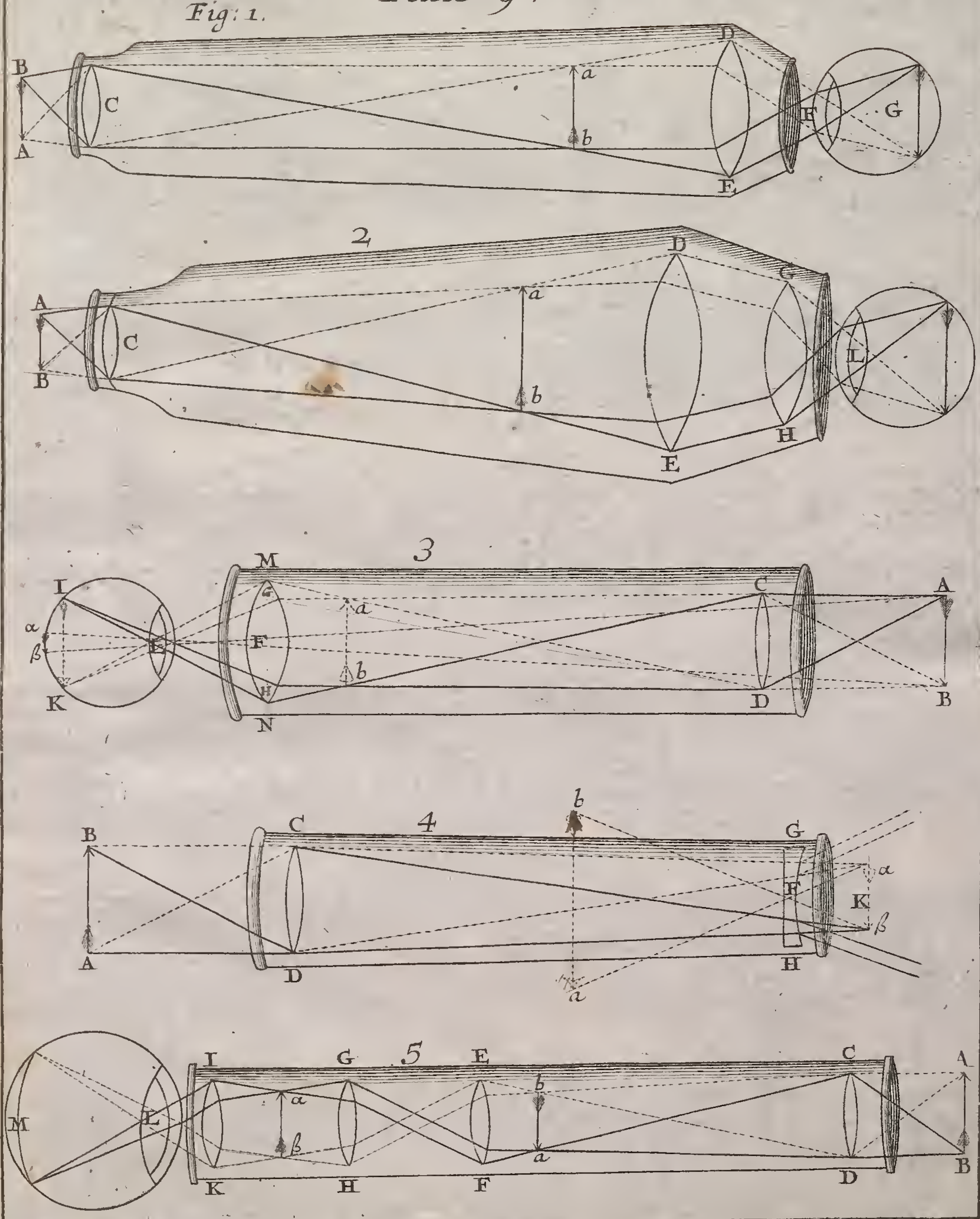
Fig: 1.
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D
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H
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B

Those Objects, wch parts are so dispos'd as to Reflect any of ye Rays (71
more yn ye Rest, & in great measure to Absorb & stifle ye othrs, appear to be of yt Colour, wch they most reflect; where a Blue Ray, wn Refracted on a Blue Objt appears much Strongr, yn wn 'tis Refracted on one of a diffrt Colr; & so of ye Rest.

If you look thro' a Prism on an Objt of any one particular Colr, (v.g.) Green, you will see in it all ye othr colours, but ye Green being ye most powerfull, ye Objt to ye Sight of ye Naked Eye will appear altogether of yt Colr.

Since White has been prov'd to consist of all Colrs, It follows frm hence yt those Objects wch appear White to us, are such as are dispos'd to Reflect all Colrs; & ye greater or less ys disposition is in ye Superficies of ye Object, it will appear accordingly of a White, or else of a Somewhat Shaded or dark Brown, or some othr intermediate Colr, & those Objts, wch are very little or not at all dispos'd to reflect those Rays, will appear Black.

It may be so Contriv'd by Darkening a Room & by yt means letting Beams of Light fall very forcibly upon a Black Objt, yt it shall appear exactly White to ye Eye.

If you Expose 2 peices of Marble to ye Sun, ye one White & ye othr Black ye Black will be Hotter, & retain ye Heat Longer; for, as ye White reflects, so ye Black absorbs all mannr of Rays, of ye Sun.

If an Oblong peice of papr plac'd before a Window, be view'd at such a distance thro' a Prism, yt ye Light falling frm ye Window on ye
Plate 10 Fig. 7. paper, may make an Angle equall to yt wch is made by it (i.e. ye Light) reflected frm ye Papr to ye Eye; provided ye Papr be terminated wth Sides $\parallel$ to ye Prism & ye Horizon, & distinguish'd by a $\perp$ transverse Line into 2 halves, ye one of an intensly Blue Colr, ye othr intensly Red; If ye Refracted Angle of ye Prism (i.e. ye 2 sides, thro wch ye Light passes to ye Eye) be turn'd upwds so yt ye paper may seem to be lifted up by ye Refraction, its Blue-Half will be lifted higher by its Refraction yn its Red-half.

But if it be turn'd downwds, so yt ye Papr may seem to be carried lower by ye Refraction, its Blue-half will be carried something lower yreby, yn its Red-half: Because in both Cases, ye Light wch comes frm ye Blue-half of ye Paper, thro ye Prism to ye Eye, is more Refracted yn yt wch comes frm its Red-half.

Finis.

Those Objects, whose parts are so dispos'd as to Reflect any of those Rays (73
more yn ye Rest. & in great measure ...

Plate 10

If

Sin

It

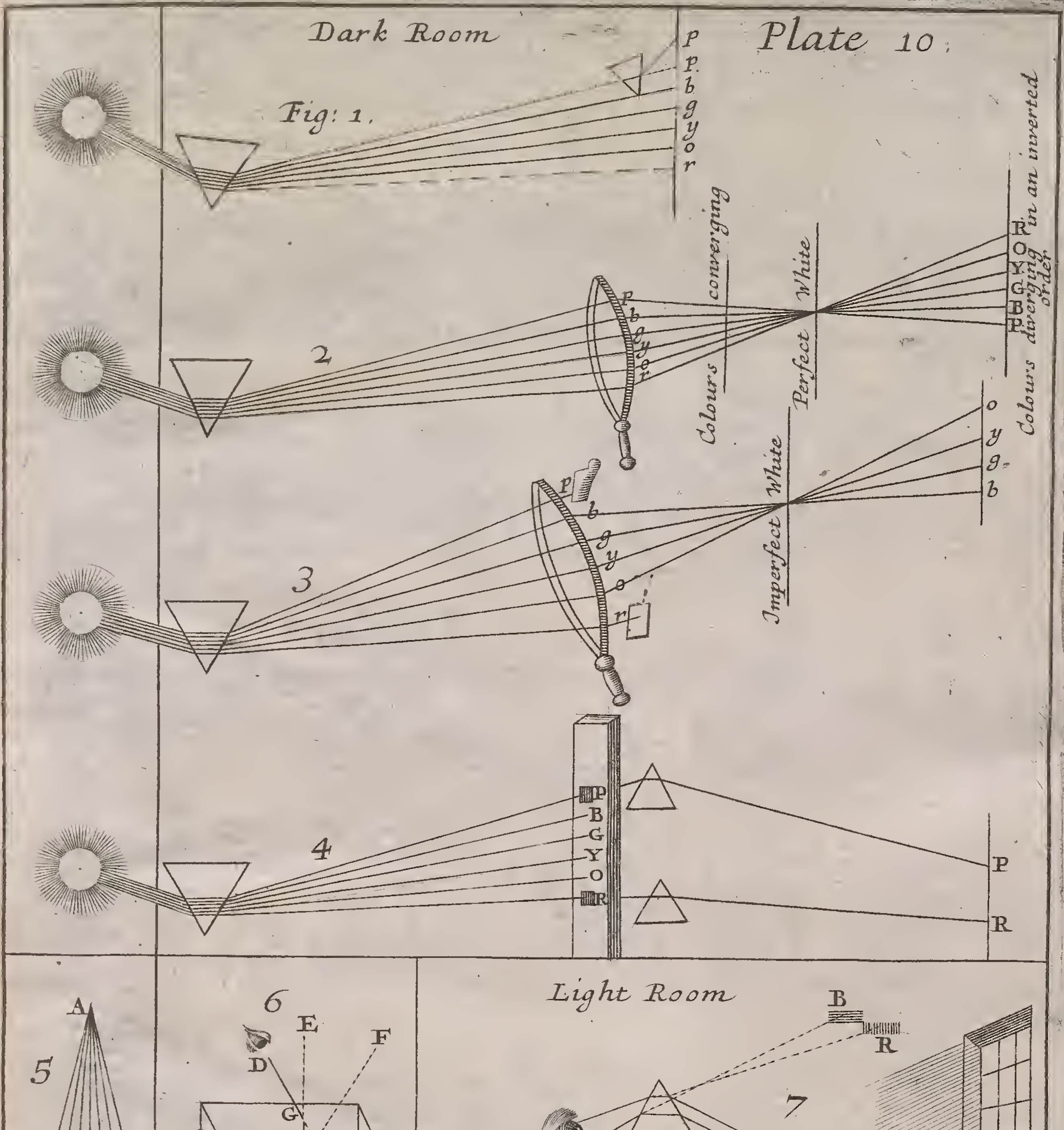
If

If

Plate

Fig. 7

B


Dark Room
Plate 10.
Fig: 1.
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b
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y
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Colours converging
Perfect White
Colours diverging in an inverted order
R
O
Y
G
B
P
3
Imperfect White
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y
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4
P
B
G
Y
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R
5
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C
E
D
B
6
E
F
D
G
H
A
B
C
Light Room
7
B
R
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r
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ω

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Finis.

Generall Law of Attraction, Sr Is: Newton
The Cause of Elasticity
of Water rising in small Tubes, Filtration
of Reflexion
of Aqua Fortis dissolving Silver, &c.
of ye motion of ye Planets.

Dub. plac. [illegible]